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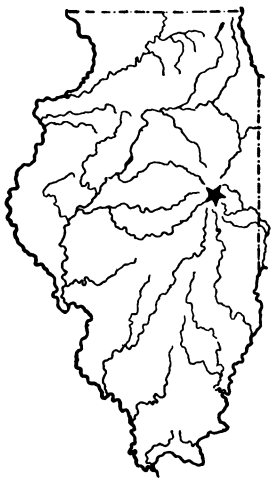
Agricultural Experiment Station.

BULLETIN NO. 95.

THE MORE IMPORTANT INSECT INJURIES TO INDIAN CORN.

GENERAL INTRODUCTION TO THE SUBJECT, AND DISCUSSION OF INSECTS INJURIOUS TO THE PLANT ABOVE GROUND.

BY S. A. FORBES,
STATE ENTOMOLOGIST.



URBANA, ILLINOIS, NOVEMBER, 1904.

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Summary of Bulletin No. 95.

1. The corn insects as a group. Pages 331, 332
2. Divisions of the corn-insect group. Page 332
3. Adaptations and reactions of the corn plant to its insect visitants. Page 333
4. General effects of insect injury. With the exception of injury to the ear, the effect of insect injury is essentially a starvation effect. Page 335
5. Any management which helps to maintain and strengthen the plant will lessen or prevent losses from insect injury. Page 336
6. General description of injuries to the leaves, to the stalk, and to the ear. Pages 336–338
7. General discussion of injuries to corn by the different orders of insects. Pages 338–344
8. The corn insects grouped or divided into "the more important," "the less important," and "the unimportant" species. Page 344
9. Synopsis of injuries by the more important insects which injure the plant above ground. Page 346
10. The corn cutworms. Twelve species discussed. Pages 347–366
11. The sod web-worms, or root web-worms. Six species discussed. Pages 366–374
12. The burrowing web-worms. Page 374
13. The stalk-borer. Page 374
14. The army-worm. Page 377
15. The corn bill-bugs. Eight species discussed. Pages 382–387
16. The chinch-bug. Page 387
17. The grasshoppers. Page 394
18. The ear-worm or corn-worm. Page 397
19. Reference to articles in the Eighteenth Report of the Illinois State Entomologist and in Station Bulletin 44, for a discussion of insects affecting the seed and roots of Indian corn. Page 399

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THE MORE IMPORTANT INSECT INJURIES TO INDIAN CORN.*

By S. A. FORBES, State Entomologist.

The Illinois State Entomologist is by law required to investigate "the entomology of Illinois," and particularly to study "the history of the insects injurious to the products of the horticulturists and agriculturists of the state," and to prepare "reports of his researches and discoveries in entomology for publication by the state." While the main end of his studies should thus be economic, the whole subject of the entomology of Illinois is nevertheless open to his investigation and report. The advancement of entomology as a science and the adaptation of entomological knowledge to educational uses, if not his duty, are clearly within the general field of his privilege. I have accordingly, in the preparation of this report, taken into especial account the rapidly rising interest in nature study as a useful feature of the work of the elementary school, and I have availed myself of the opportunity to incorporate into the present discussion much matter of little or no economic interest, but worthy of presentation, nevertheless, as material of value to the public school teacher in search of information concerning the commoner objects of his neighborhood.

The corn plant is so conspicuous a feature in the agriculture, and hence in the civilization, of Illinois, that it must always be an attractive subject of study to the youth of the state, and suitable in a multitude of cases for use in the public schools. Like most of the larger and more abundant plants, it draws to itself a considerable assemblage of insects which find in it various attractions and advantages contributing to their maintenance or their pleasure, and which thus, by their common interest in this one great plant, come to form a kind of associate group, the group of the *corn insects*. Very few of them are peculiar to the corn plant alone, since nearly all of them are equally or even more strongly attracted to other plants as well. Many of them, indeed, belong to a considerable number of such plant-insect groups, visiting or living on many other plant species, cultivated and wild.

Not one of them is immediately beneficial to the corn plant itself,

*This article contains the introduction and the first division of the Twenty-third Report of the Illinois State Entomologist. The remaining divisions of that report are devoted to the less important and the relatively unimportant corn insects.

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although a considerable number, parasitic or predaceous on other insects, are indirectly beneficial to it by relieving it to some extent from the attacks of insect enemies. Several of them do no appreciable harm at any time; others are injurious only under special conditions more or less rare; and still others are injurious to it whenever and wherever they occur. Their common interest in this one plant of course brings these insects also into important relations to each other, like those which influence any local assemblage of animals—those of a pond, of a grove, or of a barnyard, for example—and make of them a related group instead of a mutually indifferent assemblage.

It is the object of the present report to discuss this entire group of corn insects, to the end that the teacher and student, of whatever grade, may find in this paper a clue to the whole system of insect life of which the corn plant is the center. The study here presented may thus stand as in many respects a type or example of the relations of a plant to its insect visitants. While in this treatment the economic features of the system will receive full attention, this will not be to the exclusion of features of scientific or educational interest merely; but to avoid encumbering the more important economic matter with details and discussions of secondary interest, the paper is divided into sections, based on the economic relation.

DIVISIONS OF THE CORN INSECT GROUP.

The entire assemblage of corn insects is much too large and complicated for convenient discussion as a whole, and it may consequently best be divided into subordinate groups, some corresponding to the different organs and structures of the corn plant itself, others to different stages of its growth, and still others to the previous history of the land on which the corn is grown or to the situation of the field with respect to other and adjacent crops. There is, for example, a small group of insects which become abundant in corn-fields only where corn is grown on the same ground year after year—the corn root-worm is an instance—while others, like the wireworms, infest corn injuriously only when this follows within a year or two upon grass, and others, like the stalk-borer, may invade corn only from grass-lands outside. The corn root-aphis makes its main attack on the crop while the plant is young, and the leaf-aphis usually does not appear until the crop is well advanced, and continues in rapidly increasing numbers until frosty weather checks its multiplication.

Among the groups corresponding to the different parts and organs of the growing plant the most definite distinction is between those especially adapted to a life under ground, and those which never enter the earth in search of food. The white grubs, wireworms, corn root-worms, seed-corn maggots, and root-lice are on one side of this dividing line, and the

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chinch-bug, army-worm, corn-worm, leaf-louse, and a host of additional species are on the other. Among the subterranean corn insects we may distinguish a few which feed only on the softened seed in the earth; others confined to the living roots; other root insects which may extend their injuries to the underground part of the stalk; and still others which may also eat the seed.

While the relations of the injurious species of corn insects to the plant thus differ widely, making it possible to divide the species according to these relations, groups so formed are by no means as definite and sharply limited as those in a classification based on form and structure, but they overlap and intermingle variously, and may even undergo radical change with the lapse of time—a change corresponding to a change of habit in a species with the changing conditions around it. This is merely saying in other words that the actions, behavior, habits, and preferences of insects are more flexible and variable and far more readily adaptable than such of their structures as are used in their classification.

ADAPTATIONS AND REACTIONS OF THE CORN PLANT TO ITS INSECT VISITANTS.

There is little in the structure or the life history of the corn plant to suggest any special adaptation to its insect visitants—no lure to insects capable of service to it, or special apparatus of defense against those especially liable to injure it. The fertilization of its seed is fully provided for without reference to the agency of insects, and would be as well accomplished if none of them ever carried pollen from the tassel of one plant to the silk of another. Hence the plant secretes no honey and has no floral odor or colored bloom. It has no armature of spines or bristly hairs to embarrass the movements of insects over its surface or to defend against their attack the softer and more succulent foliage at its growing tip. It secretes no viscid fluids to entangle them, and forms no chemical poisons or distasteful compounds in its tissues to destroy or repel them. The cuticle of its leaf is neither hardened nor thickened by special deposits; its anthers are neither protected nor concealed; and its delicate styles—the silks at the tip of the ear—are as fully exposed as if they were the least essential of its organs. Minute sucking insects are able at all times to pierce its roots and its leaves with their flexible beaks, and with the single exception of its fruit there is no part of it which is not freely accessible at any time to any hungry enemy. Only the kernel, which was lightly covered in the wild corn plant by a single chaffy scale or glume, has become, in the long course of development, securely inclosed beneath a thick coat of husks, impenetrable by nearly all insects; and we may perhaps reasonably infer that among the possible injuries

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against which this conspicuous protective structure defends the soft young kernel those of insects are to be taken into account.

There are also, of course, many insect species, even among those which habitually frequent the plant, which are unable to appropriate certain parts of its substance to their use, but this is because of the absence of adaptation on their part and not because of any special defensive adaptation on the side of the plant. The adult or beetle of the corn root-worm (*Diabrotica longicornis*) is an example. The larva of this insect feeds only on the roots of corn, and the beetles consequently all make their first appearance for the year in corn-fields, and find their food at first on the corn plant. Owing, however, to the weakness of their jaws they are unable to eat the leaves of corn, and feed only on the fallen pollen and the young silks just growing out from the husks. Later, as the pollen disappears and the silk dries up, they are driven to other plants, or even compelled to leave the field entirely in search of food, and hence are found at that time on clover heads and on the flowers of thistles and ragweed and other late-blooming plants.

Thus we may say that with the exception of the ear the whole plant lies open and free to insect depredation, and that it is able to maintain itself in the midst of its entomological dependents only by virtue of its unusual power of vigorous, rapid, and superabundant growth. Like every other plant which is normally subject to a regular drain upon its substance from insect injury, it must grow a surplus necessary for no other purpose than to appease its enemies; and this, in a favorable season, the corn plant does with an energetic profusion unexampled among our cultivated plants. Insects, indeed, grow rapidly as a rule, but soon reach their full size. Many species multiply with great rapidity, but even these the corn plant will outgrow, if given a fair chance, provided they are limited to corn itself for food.

The great injuries to corn by insects are done by species which come into it from other and earlier crops; insects which are in the full tide of their multiplication, or perhaps at their maximum number for the season, while the corn plant is still small and young. It is not the corn root-aphis which injures corn most seriously, although confined to the corn plant and endowed with a power of multiplication scarcely surpassed among insects; it is the chinch-bug, which breaks into the field of young corn from adjoining wheat or oats, where it has already increased a hundredfold since spring began; it is the army-worm or the cutworms or the wireworms or the white grubs, which began and got most of their growth in grass, and now, by their numbers and voracity, overwhelm the young corn before the time of its most rapid growth has arrived. Practically limited to this vigor of growth as a means of escape from insect attack, anything which checks or retards its growth for a considerable time has, of course, the effect to increase insect injury.

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Thus, a cold and backward spring after corn-planting increases injury to the seed and the young plant by wireworms, seed-corn maggots, and the corn root-aphis; and a midsummer drouth greatly increases the effect, if not the amount, of injury by chinch-bugs, white grubs, and the corn root-worm.

GENERAL EFFECTS OF INSECT INJURY.

With few exceptions, the effects of injury to corn by insects, where they do not amount to a total destruction of the plant, may be compared to the effects of simple starvation. Anything which lessens the store of food laid up in the corn kernel for use in germination and early growth, or damages seriously the roots or the leaves, or draws away the sap before it has served its purpose in the plant, practically amounts to a diminution of the available food supply. An impoverished soil, very dry weather, the sapping of the cells and vessels of the plant by sucking insects, destruction of any considerable part of its roots, and the deadening or destruction of any large percentage of its leafage, all have similar consequences, which may be classed as starvation effects, and when two or more of them coincide, each serves, of course, to intensify the effects of the others.

One common result of these starvation injuries to corn is the failure of the plant to form the ear; the stalk itself, perhaps, making a fairly vigorous growth, but remaining barren, and hence useless except for fodder. Injury to the roots, if continuous and severe, has, however, another effect, of a more special character, in so weakening the hold of the plant on the earth that the stalk readily falls after it has become top-heavy with growth, and is not able to rise again. This happens after soaking rains have softened the ground, especially if accompanied by heavy winds. It is sometimes a consequence of the destruction of the roots by the corn root-worm and the white grubs, and is sometimes due to chinch-bugs, which, by sucking the sap from the base of the stem, prevent the formation of the strong "brace-roots"—the upper circle of roots—put forth during the last stages of the growth of the stalk. Actual loss of roots sometimes also delays the development of the plant, acting in this respect like an unusually cool summer. Thus, a field infested by grubs or root-worms may remain green after uninjured fields are practically ripe. Such backward fields are especially exposed to injury by frosts, and hence are likely to yield an unusual amount of soft corn.

Besides this class of general injuries, which diminish the vitality and lessen the size or delay the growth of the whole plant, there remain only the more local injury to the ear, caused almost wholly by the caterpillar known as the corn root-worm, and the damage done to the ear in the crib or to the kernel in the bin by the weevils and other insects of similar

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habit. With respect to their economic mischief, there is probably little to choose between those insects which, by destroying or weakening the plant, prevent the development of the ear or diminish its size and those which destroy the mature product. One deprives the farmer of the reward of his labors and investments as completely as the other.

General Measures of Prevention and Remedy.

From what has been said above with respect to the starvation effect of most insect injuries, it follows that any management which helps to maintain and strengthen the plant by furnishing it better or more abundant food will lessen, or perhaps wholly prevent, losses from insect injury which must otherwise be serious or complete. A strong, rich soil, well cultivated, well watered, and well drained, may grow a good crop notwithstanding an amount of infestation by chinch-bugs, root-lice, root-worms, and white grubs which would be fatal on poor or poorly managed land. The good corn farmer may thus escape with a profitable yield under insect attacks which will leave his less intelligent or less careful brother in debt after his crop is harvested. This is not merely because the vigorous plant will easily support an amount of injury under which the unthrifty one will suffer or succumb. It is an established fact that many insects themselves will not thrive as well or multiply as rapidly on a vigorous, quickly growing plant as on one in feeble condition.

More special measures are a proper rotation of crops, such that corn shall not be exposed to injury by insects which have bred on the same ground the preceding year, either in other crops or in corn itself; timely plowing, to forestall the breeding of insects by destroying them or their food; timely planting, with reference to the period of the greatest abundance or greatest activity of certain species; and the use of barriers against the movement of certain destructive species into the corn from fields adjacent, combined with insecticide measures against hordes or companies of destructive insects, which if left to themselves will work great and immediate harm.

Insect Injuries to Different Parts of the Corn Plant.

To the Leaves.—That the abundant, conspicuous, and easily accessible foliage of the corn plant should attract a large number of hungry insects and suffer more from their attentions than any other part, is naturally to be expected, since, as a consequence of its gradual and long-continued growth, it offers for consumption during many months the most succulent and nourishing food which the plant produces.

More than one hundred species of insects, representing all of the orders injurious to corn, have, in fact, been found feeding on the leaves. The most important differences in their injuries are due to differences in the mouth-parts of the insects—whether sucking or biting—and the

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principal differences subordinate to these are due to differences in size, number, and feeding habits of the insects concerned.

A sucking insect, merely piercing the tissue with the delicate bristle-like structures of its beak and withdrawing from the adjacent parts the more fluid portions of the cell contents, may, if very small, drain and deaden only a few neighboring cells, thus causing a minute discolored speck, insignificant unless these injuries are very numerous. Such are the injuries done by leaf-hoppers and others minute sucking species of active habit, each deadened speck evidently representing a single meal of the insect, which moves to another point, or perhaps to another plant, for its next. Plant-lice, on the other hand, which change their location with difficulty and reluctance, each remaining, as a rule, about where it was born, accumulate in patches or colonies as they multiply, and, closely occupying a larger surface, so concentrate their injury as to do much more serious damage. If injuries of this sort are greatly multiplied, as by multitudes of the chinch-bugs, the whole leaf is killed outright.

Gnawing and biting insects differ similarly with respect to the magnitude and seriousness of their injuries. Some of the small size with feeble biting organs merely gnaw away the more superficial and softer parts of the leaf, leaving the vein structures untouched, and causing discolored specks not unlike those due to leaf-hoppers; somewhat larger kinds make small holes through the leaf like pin-pricks or shot-holes; and still larger ones, such as grasshoppers, eat away the edge of the leaf or gnaw large and irregular holes through it, avoiding nothing but the heavy midrib and the stronger veins. Grasshoppers sometimes strip the whole leaf to the midrib, and eat away all but the tougher and thicker part of this.

Curious parallel rows of precisely similar holes, running across the corn leaf, are made by the corn bill-bugs, which thrust their stiff snouts, or "bills," into the young plant where its leaves are rolled together, and eat out the interior by means of minute jaws borne at the tip of the snout.

To the Stalk.—The stalk of the plant is injured by the loss of sap drained away by sucking insects, of which the chinch-bug is the most destructive; by a mining of its interior by caterpillars, like the stalk-borers, which enter it from the outside; by the punctures and feedings of the corn bill-bugs, which sink their beaks into its substance and eat out its soft interior tissue; and by the gnawing of a few larger beetles (*Ligyrus, Allorhina*, etc.), which eat out large cavities in its side. It is similarly gnawed and irregularly eaten, when young, by sod web-worms; it is cut off at or near the ground by cutworms, and in rare instances by ants (*Pogonomyrmex barbatus*); and devoured, with the rest of the young plant, by army-worms and garden web-worms. Under ground it may be gnawed out or eaten through from side to side by wireworms,

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or irregularly mined by the small, soft-bodied larva known as the southern corn root-worm (*Diabrotica 12-punctata*).

To the Ear.—Injuries to the ear are of two principal kinds: the kernels may be eaten beneath the husk by a large green or striped caterpillar which bores in from the outside and feeds irregularly about, fouling the ear with its excrement; or the silks may be gnawed away from the tip of the cob at a time to interfere with the process of fertilization, and thus to blight the kernel. Small damage is also done by various beetles, caterpillars, and grasshoppers, which gnaw away the kernels at the tip of the ear where these are exposed by the opening of the husks. This injury, however, is mainly confined to ears upon the ground or to those which have been previously visited by birds. Sometimes the husks are largely eaten away by grasshoppers, together with the softer parts of the young ear itself.

INJURIES TO CORN BY THE DIFFERENT ORDERS OF INSECTS.

Hymenoptera: Bees, Wasps, Ants, etc.—With the exception of a small bee (*Halictus lerouxi*) frequently seen gathering corn pollen from the silk, leaves, and husks, but responsible for neither injury nor benefit to the plant, various kinds of ants are the only insects of this order which occur frequently in fields of corn.

Ants are among the most active, observant, and capable of all insects. Their restless and wide-ranging habits bring them into acquaintance with every variety of objects in their neighborhood, and little escapes their notice or their appropriation which can in any way be converted to their support. The abundance of certain species in corn-fields in spring, shown especially by their burrows in and near the hills of corn, is a matter of common observation. Even in fall after frost, or during the warmest days of an open winter, these enterprising rangers may be seen climbing over the dead stalks or coursing irregularly about upon the bare earth; and many of them pass the winter in burrows or nests among the corn roots, where they are turned out in the spring plowing with eggs and larvæ in their possession.

A few corn-field ants are directly injurious to corn by hollowing out the softened and sprouting kernels in the earth, thus either preventing its germination, killing the young shoot, or weakening it by appropriating the stored food necessary to its earliest growth. The common house-ant has been once or twice reported to gnaw the young corn leaf and drink the sap exuding from the wounds thus made. One species of southern leaf-cutting ant bites out pieces of the corn leaf, which it carries away to its underground burrows, and certain other ants are found occasionally about the tips of the green ear feeding on kernels which have been injured previously by other insects or by birds.

Direct injuries of this class are, on the whole, economically insig-

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nificant, but a few kinds of ants are capable of an indirect injury to corn which often becomes extremely serious. By the care and assistance given to plant-lice, or aphides, which infest the roots and leaves of corn, they greatly extend and increase the injury done by these insects which they have in charge. This injury is mainly due to ants which live in corn-fields throughout the year, reinforced as they are by newcomers from adjacent grass-lands in early spring. In their underground nests in the field they collect in fall the eggs of the corn root-aphis, and in spring they place the young hatching from these eggs on the roots of suitable food-plants. As these grow and multiply, the ants transfer them from one plant to another as necessity may arise, devoting themselves to their welfare with a constancy and patience, due not to charity, as it might seem, but to an enlightened regard for their own best interests. Throughout nearly the whole season, indeed, these ants are dependent on their helpless charges for food, which they find in the abundant fluids given off by the plant-lice as these suck the sap from the growing plant.

To the ant the plant-lice are living automatic pumps, constantly drawing from the tissues of the plant excessive quantities of sap, abstracting from this only a part of its food material as it passes through their bodies, and giving it forth again in condition to serve a second time for the support of insect life. A similar benefit is derived by other species of ants from the corn leaf-aphis, but this insect is only slightly injurious to corn, and the ants are less essential to it. Nothing is known, for example, to indicate that the eggs of the leaf-aphis are cared for by ants, and, indeed, no eggs of this species have ever been found.

With the exception, therefore, of the various species of ants which attend the corn root-louse in the earth, injuries to corn by these insects may be practically ignored as insignificant, and at worst as not serious enough to require or warrant attempts at measures of prevention.

Diptera: Flies and Gnats.—Among the multitudes of two-winged flies, or *Diptera*, only a few are found frequently on or about the corn plant, and scarcely one of these is likely to do it any serious injury. The winged insects themselves are never injurious to corn, all the harm done by these insects to this plant being through their larvæ or maggots only. When corn has followed upon clover, the roots of the young plant have rarely been injured by the large, dirty-looking, grub-like larvæ of one or two of the crane-flies (*Tipulidæ*); the planted seed is sometimes eaten to some extent by the small seed-corn maggot (*Pegomyia fuscipes*); the leaves are occasionally mined in a very small way by two or three mining maggots (*Diastata* and *Odontocera dorsalis*); and the larva of a Syrphus fly, which commonly feeds on the fallen pollen lodged in the tassel or at the tip of the ear or at the base of the leaf, is reported sometimes to puncture the leaf for the sake of the sap. Other Syrphus larvæ

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doubtless compensate fully for these small injuries by feeding on the corn leaf-aphis, of which they are very fond.

The sole measure of prevention suggested by these facts relates to the so-called meadow maggots, the tipulid larvæ mentioned above. These insects are found in injurious numbers only in meadow-lands where they have hatched from eggs laid in grass or clover, and corn should not be planted on sod which was badly infested by these the preceding year.

Lepidoptera: Butterflies, Moths, and Caterpillars.—Caterpillars of about fifty-six species have been collected or reported from the corn plant, feeding on the stalk, the leaf, and the ear, or in some cases devouring the young plant entire. The principal injurious groups are the cutworms, the grass-worms, the army-worm, the web-worms, the stalk-borers, and the so-called corn-worm, which penetrates the husks and mines in the grain beneath. Of these, the cutworms, the army-worm, and the corn-worm are by far the most destructive. A few other caterpillars (*Hadena* and *Prodenia*), allied to the cutworms but having a different habit, are much less injurious.

Some seventeen species of cutworms have been taken in corn, all of similar habit with respect to corn, but very considerably different in life history—a fact which has an important bearing on measures for their control.

The stalk-borers, which penetrate the stalk and burrow within it, are the common species of that name (*Papaipema nitela*), the spindle-worm (*Achatodes zeæ*), the southern corn-stalk-worm or sugar-cane borer (*Diatræa saccharalis*), the smaller corn-stalk-borer (*Elasmopalpus lignosellus*)—also essentially a southern species—and a caterpillar (*Helotropha reniformis*)—a northern species which does not injure corn in Illinois, but which has been known to destroy it in Michigan by burrowing along the center of the young stalk. In fact, only the common stalk-borer is commonly abundant enough in Illinois to rise to economic importance.

The grass-worm (*Laphygma frugiperda*) is a pest of common occurrence, but is ordinarily economically insignificant. Occasionally it multiplies in here and there a place in a way to cause serious mischief, although it has but once been found by us (in 1889) notably destructive to corn.

The army-worm does not breed in corn-fields, and is rarely found there except when its numbers force it to migrate, but then it often lays the field absolutely bare by devouring every plant to the ground. The turf web-worms (*Crambus*) are sometimes very destructive locally in Illinois to young corn after grass, and the garden web-worms (*Loxostege*) are even more injurious in the west-central states. The corn-worm (*Helio-*

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this armiger), called also the cotton boll-worm in the South, is very generally and seriously injurious to corn in the ear.

The only groups of these caterpillars against which it is practicable or necessary to use special measures of protection in Illinois are the army-worm, the cutworms, the web-worms, and the stalk-borers, injuries by other species being either too trivial or too infrequent to warrant special precautions, or, like those of the corn-worm (*Heliothis armiger*), uncontrollable by any measures as yet devised and tested. Cutworms, web-worms, and stalk-borers may be virtually prevented from doing serious damage to corn by a proper arrangement and rotation of crops, and by an intelligent selection of times and methods of handling and plowing grass-lands previous to planting them to corn. The army-worm must be excluded from the field by barriers to its progress when it is on the march, and destroyed as it collects before such obstacles. A fuller discussion of these various measures will be found in connection with the special articles on the groups themselves.

Coleoptera: Beetles.—Approximately ninety species of beetles have been identified as corn insects in either the larval or adult stages, a few of them in both. Not more than one-third of these species, however, need be mentioned in a merely economic list, and if we do not attempt to distinguish for economic purposes between the different kinds of white grubs and of wireworms which infest corn under ground, the list so reduced will contain less than a dozen names.

The habits of the adult beetle and those of its larva are in most cases so widely different that instances are few in which we find both stages of the same insect infesting corn, and there is not a single case known to me in which a *similar injury* is done to corn by both. The beetle larvæ injurious to corn all live under ground, and their injuries, consequently, are confined to the planted seed, the roots, and the underground part of the stalk. The adult beetles, on the other hand, may eat any part of the plant, from the seed and roots to the silk and kernels of the ear.

By far the most serious injuries due to beetles are done by their larvæ, especially by those known as wireworms, white grubs, and corn root-worms. The only injuries by the adults themselves deserving to be classed with these, are those due to the so-called bill-bugs of the genus *Sphenophorus*.

Besides these major enemies, whose attacks are largely preventable, there is a swarm of minor or occasional enemies against which it is both useless and needless to contend. Several of the ground-beetles (*Carabidæ*), for example, eat the kernel from the tip of the ear, and one small abundant species (*Agonoderus pallipes*) has occasionally done considerable harm by devouring the seed and the roots of the young plant.

Several small species of the family *Phalacridæ*, and others of the *Nitidulidæ*, similarly infest the ear, and the larvæ of one of them, *Ips*

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4-guttatus, has once or twice been known to eat the planted seed. Two or three of the small dung-beetles and some of the leaf-chafers do similar injuries to the kernel on the ear or in the ground. A number of the latter group occasionally injure the young plant by devouring the leaves or eating into the stalks. Larvæ of two of the short-horned borers (*Prionus*) have been reported as rarely injurious to the roots of corn, and a considerable number of the plant-beetles, flea-beetles, and the like (*Chrysomelidæ*), are variously destructive to practically all parts of the plant.

The wireworms, white grubs, and bill-bugs are all primarily grass insects (the first and third much more strictly so, however, than the second), and their attacks, consequently, may be forestalled wholly or in great part by a proper management of the land with respect to rotation, and especially by using care in changing the crop from grass to corn. The corn root-worm, on the other hand, is a corn insect only, and its mischief may be promptly and completely arrested in any case arising, by planting corn on land not in that crop the preceding year.

Hemiptera: True Bugs.—Although not less than forty-five recognized species of bugs have been found sucking the sap from some part of the corn plant in the field, to say nothing of several others which have not been exactly identified, only one of this long list is a corn pest of the first class, but this (the chinch-bug) is, on the whole, by far the most destructive insect enemy of this plant in America.

The false chinch-bug (*Nysius angustatus*) has occasionally injured corn severely in our territory, making its way into the field from infested wheat adjoining, and the tarnished plant-bug (*Lygus pratensis*) has rarely been found responsible for noticeable injury. The corn root-aphis (*Aphis maidi-radicis*) is capable of killing young corn by sucking the sap from its roots, but more frequently it merely retards the growth of the plant in spring, or perhaps permanently dwarfs it by this early drain on its vitality. The corn leaf-aphis (*Aphis maidis*) may kill some of the older leaves later in the season, but although it often continues to increase in numbers until frost checks its multiplication, it can rarely be said to diminish sensibly the amount or to impair the quality of the crop. Otherwise, the various sucking insects which are found on the corn plant obtain from the leaf, the stalk, the tassel, the silk, the husk, or sometimes from the soft young kernels exposed at the tip of the ear, an amount of liquid food too small to affect the growth of so vigorous a plant.

Special preventive measures are necessary or profitable, as a rule, only against the chinch-bug, and will be discussed in connection with that insect, although injuries by minor species may be reduced by clean culture, by the destruction of winter harborage for insects, and by a few

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other general measures characteristic of intelligent and careful agriculture.

Orthoptera: Grasshoppers, Locusts, and Crickets.—About twenty-five species of *Orthoptera* have been noticed as common in corn-fields, the larger number and the only destructive species belonging to the so-called short-horned grasshoppers (*Acrididæ*). Like very many other insect visitants to the corn-field, these *Acrididæ* are normal grass insects, and go into the corn in numbers sufficient to attract attention only when their usual food threatens to fail, and their injuries are consequently confined at first to the edges of fields adjoining pastures and meadows. The great migrating grasshopper of the Western Plains is, of course, an exception to this statement, and an occasional migrant swarm of certain Illinois species imitates with some success the practices of this western insect, settling upon a field like a flock of birds, and doing a general injury.

The ordinary grasshopper attack on corn is rarely made by the young, and is consequently postponed, as a rule, until late summer or early fall, when the corn is practically full grown and the insects are able to fly. Where the injury is severe the leaves are eaten away to the tough midrib, the husks are gnawed from the ear, and the latter, if still young, is itself devoured, little but bare stalks remaining about the edges of the fields. Fourteen species of short-horned grasshoppers are on our list of those injuring corn in this way.

The long-horned grasshoppers (*Locustidæ*), including the meadow grasshoppers, climbing crickets, and the like, are not uncommon in corn-fields, but they are only slightly injurious to that plant. One of them, *Orchelimum xulgare*, has occasionally been seen to eat the leaves, silk, husks, and grain, and many other species sometimes gnaw away a few kernels from the tip of the ear. Several kinds of these insects frequently lay their eggs in the slender part of the corn-stalk, in or below the tassel of the ripened plant, but their food consists mainly of pollen, fungi, plant-lice, etc., and indicates no injury to corn.

Two of the common crickets (*Gryllus abbreviatus* and *Nemobius fasciatus*) sometimes injure the ripened ear, especially where there are many fallen stalks in the field, by creeping in beneath the husks and gnawing off the surfaces of the kernels.

The only possible protection to corn against grasshoppers is the destruction of these insects before they leave the grass-lands adjoining, or when they first enter the corn-field. Once generally distributed in the fields, practically nothing can be done to arrest the injury. For their destruction in pastures and meadows, some one of the methods must be chosen which has been found effective against these insects in the West. These are, generally speaking, the plowing in fall of ground heavily stocked with grasshoppers' eggs, or plowing even in summer for the

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destruction of the young, the burning over of grass-lands after the young have hatched, the collection of the egg masses where these have been abundantly deposited, poisoning heavily the outer rows of corn with arsenic or Paris green, distributing along the edges of the field quantities of poisoned horse-droppings, the so-called Criddle mixture, and catching the insects in meadows and pastures by the use of the "hopper-dozer." The most important of these procedures will be more fully discussed on another page.

Neuroptera: Dragon-flies, Lace-wings, etc.—No insect injurious to corn belongs to the order *Neuroptera*, which, in fact, need be mentioned in this connection only to say that the occasional abundance in corn-fields of the delicate and interesting lace-wing fly (*Chrysopa*) is to be connected with the occurrence of plant-lice there, upon which both larval and adult lace-wings feed. The winged insects we have found in corn-fields eating the spores of fungi, the surface hairs of the leaf, and other delicate vegetable tissues.

Acari: Mites.—The mites commonly known as the red spiders (*Tetranychus bimaculatus* and *T. modestus*) have been rarely found injurious to the young corn leaf, causing a rusty or brownish discoloration. This injury to corn seems to have been too rare, however, to be worthy of special attention, although the wide-spread distribution and destructive capacity of these insects suggest the possibility that they may be responsible for greater injury to this plant than has been attributed to them.

Myriopoda.—Several species of millipedes and centipedes are occasionally encountered in corn-fields doing a slight and infrequent injury only, by gnawing into the kernels beneath the husks. They are most likely to injure ears which touch the ground, but sometimes climb the stalk as much as two or three feet.

THE CORN INSECTS GROUPED ACCORDING TO THEIR ECONOMIC IMPORTANCE.

The number of insects infesting corn is so very large, and the proportion of them which are seriously injurious to that crop is comparatively so small, that it is necessary, for practical reasons, to separate the important insects from the remainder in this discussion. I have consequently divided the entire list of corn insects into three groups, according to their economic importance, placing in the first group of "the more important corn insects" those which do so serious an injury to the crop that every corn-grower should know the principal facts concerning them as an essential part of his knowledge of farming; in the second group, of "the less important" insects, those which are sometimes definitely injurious but ordinarily do no great harm; and in the third group, of "unimportant" insects, those which do little or no injury to corn as a farm crop,

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and which may, consequently, be practically ignored by the farmer as insignificant.

I have thought it best that the first group should be made as small as is reasonable and safe, and have placed no species in it which there was not positive reason to consider as a destructive corn pest. The second group, on the other hand, I have made to include all of the other species which are known to have any tangible economic significance whatever.

The first group may be said to contain those species concerning which every practical corn farmer should know the essential facts; the second group, those additional species which should be familiarly known to the economic entomologist; and the third group, those which are of interest chiefly to the general entomologist—the student of entomological ecology—who wishes an exhaustive knowledge of the entomology of the corn plant.

Notwithstanding this distinction, it should be remembered that negative knowledge is sometimes little less valuable than positive; that it may sometimes be as interesting, and even as important, for a farmer to know that a species appearing for the first time in his fields is not definitely injurious as it is to recognize it at once as an insect enemy. The more he can learn, consequently, of the great association of corn insects treated in this report, the better prepared he will be to handle his crop intelligently under all conditions.

It must, of course, be admitted that the dividing lines between these groups are more or less arbitrary, and at best but poorly defined, the division between the first and second being especially hard to establish. An insect may be highly important to corn culture at some times and in some parts of the country, and of little or no importance elsewhere and ordinarily, and differences of judgment will unavoidably arise as to the group in which a given species should be placed. The history of economic entomology makes it also virtually sure that certain species now properly placed in one of the less important groups will require hereafter to be transferred to a more important one, and the group division here proposed may, on this account, become more or less inaccurate in course of time.

The reverse proposition is, however, much less likely to be true. It will rarely occur that a species once recognized as seriously destructive to corn will drop to an inferior place on the list. It sometimes happens, indeed, that an alien insect species is much more numerous and destructive for a few years following upon its first appearance in the country than it ever is again, but, as a matter of fact, no single corn insect of any considerable importance is such an alien species—has come into the country, that is to say, since corn became an important American crop.

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It is possible, also, that the normal progress of agriculture may make virtually universal, farming practices which will serve as permanent preventives of injury by certain insects which have previously done great harm. If, for example, it should become the general rule to raise corn on the same ground for only two or three years at a time, injuries by the corn root-worm would apparently be reduced to insignificance. No such event has anywhere occurred in this country, however, and the rule of economic entomology has thus far been "once an enemy always an enemy," the list of insect pests increasing from time to time, but never diminishing.

DISCUSSION OF SPECIES.

In the remainder of this report I give all pertinent facts of any importance known to me concerning the corn insects which frequent that part of the plant which grows above the surface of the ground, exclusive, however, of those which infest the grain or the fodder after these have been removed from the field. In order to make this treatise virtually complete for the corn insects as a group, I have made references, at the end, to a previous article on injuries to the seeds and roots of Indian corn, published in my Seventh Report as State Entomologist—the Eighteenth of the office series—and also, in briefer form, in Bulletin 44 of the State Agricultural Experiment Station. The above-mentioned Eighteenth Report may be found in volume 31 of the Transactions of the Illinois State Department of Agriculture, where it is printed as an appendix.

ECONOMIC GROUP 1.

(The more important insects: those seriously injurious to the crop, either as locally and occasionally destructive or as widely and frequently harmful.)

INSECTS INJURIOUS TO THE PLANT ABOVE GROUND.

SYNOPSIS OF INJURIES.

PAGE

The plant cut off when young at or near the surface of the ground by a whitish, grayish, or blackish caterpillar frequently found in the earth near the injured plant ..... Cutworms (*Agrotis, Hadena*, etc.). 347

The stalk of the young plant eaten into or irregularly gnawed off. The leaves also irregularly eaten. A small, spotted reddish caterpillar found under ground near the base of the plant in a small mass of earth held together by a web ..... Sod Web-worms or Root Web-worms (*Crambus*). 366

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PAGE

The stalk of the young plant penetrated by a round hole which is more or less plugged by excrement. The interior of the stalk irregularly eaten out by a striped burrowing caterpillar..... .....The Stalk-borer (*Papaipema nitela*). 374

The entire plant more or less completely eaten, the leaves first and then the stalk, in June and early July, by hordes of traveling striped caterpillars commonly coming into the field from one side.....The Army-worm (*Leucania unipuncta*). 377

The stalk punctured and slit, the leaves perforated by round or oblong holes arranged in parallel transverse rows. Hard-shelled, oval, black or clay-colored snout-beetles often found, head downward, on the stalk near the ground or a little beneath the surface..... Corn Bill-bugs (*Sphenophorus*). 382

Plant wilted or sickly, leaf-edges and lower leaves turned yellow or brown, many small red or dusky, or blackish and whitish bugs behind the leaf sheaths of the corn, or clustered on outer surface of the stalk..... The Chinch-bug (*Blissus leucopterus*). 387

The leaves of the plant variously eaten, sometimes stripped to the midrib, about the borders of the field, in late summer or fall. The silks and husks also more or less eaten away..... ..... Grasshoppers (*Acrididæ*). 394

The husk of the ear perforated by a round hole with the excrement exuding, the corn mined beneath by a brownish, or greenish, striped caterpillar....The Ear-worm or Corn-worm (*Heliothis armiger*). 397

THE CORN CUTWORMS.

Hadena devastatrix Brace.
H. arctica Boisd.
Agrotis ypsilon Rott.
Peridroma margaritosa saucia Hübn.
Noctua c-nigrum Linn.
Feltia subgothica Haw.
F. jaculifera Guen.
F. gladiaria Morr.
Nephelodes minians Guen.
Hadena lignicolor Guen.
Noctua clandestina Harr.
Feltia annexa Tr.
Euxoa messoria Harr.
E. tesse lata Harr.
E. ochrogaster Guen.
Mamestra renigera Steph.

The caterpillars commonly known as "cutworms" destroy the young corn plant by eating the leaves, gnawing into the stalks, and cutting off the plant close to the ground at night, often dragging the severed part into their holes near by. They hide by day under clods, or by burying themselves a little distance in the earth, where they may be easily found curled up into a close spiral or a circular disk. They are thick, soft-bodied, rather sluggish caterpillars, with nearly smooth skins, varying in color from whitish to dark brown, variously marked, in many cases with longitudinal stripes, and often with dark dashes and blotches addi-

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tional. They are most destructive in corn following on grass or clover, but sometimes come into the field from meadow or pasture lands adjoining, when the outer rows of corn, of course, suffer worst. Where they are very numerous it is virtually impossible to obtain a stand of corn until the period of their active injuries is passed. Many of them, when they become so numerous on any spot as to overtax their food supply, move out of the overpopulated field in companies not unlike those of the notorious army-worm. The latter belongs, indeed, to the cutworm family, and when only ordinarily common lives and feeds, generally speaking, like the cutworms of this list.

Most of the species pass the winter partly grown, and are consequently prepared to make their attack on corn as soon as it shows above ground. They enter the earth for their transformations when full grown, at times varying for the different species, most of them in late June or early July. They change in the earth to leathery, brown pupæ, from which grayish or brownish night-flying moths—the adults of the species—emerge later in the season, and, laying their eggs in grass-lands, perish before the winter. The young hatching from these eggs live on the roots of grasses until cold weather, doing no noticeable injury, as a rule, during this fall period.

The greater part of them develop, in our latitude, only a single generation each year, but a few of the most destructive species are two- or three-brooded. This fact seems to make little difference, however, from the economic point of view, except as the single-brooded species are less able than the others to take prompt advantage, by their rate of increase, of specially favorable conditions of location, crop, or weather of the season.

Injury to corn by cutworms is best prevented by midsummer or early fall plowing of grass-lands to be planted to corn; by pasturing pigs on grass or clover lands to be plowed up for corn; by distributing, by the aid of a seed-drill, a line of dry bran or middlings, poisoned by mixing in Paris green at the rate of a pound of the poison to thirty pounds of the food-stuff, or by scattering poisoned food in spring along the borders of corn-fields next to grass; and by replanting when corn is killed by them, postponing this step, however, until the cutworm injury has practically ceased for the season. The earlier the preceding year grass-lands to be planted to corn are plowed, the less will be the probability that the cutworm moths will have laid their eggs thereon, and the less, consequently, will be the danger of injury by cutworms the following year.

The points in the life history of the various cutworms essential to successful management are thus the time when the greater part of the eggs are laid for the hibernating brood of the caterpillars, and the time when this hibernating brood gets its growth in spring, ceases its injuries, and goes into the ground for its change to the pupa state. The first

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date shows when the ground should be plowed for corn in fall; and the second, when it may safely be planted or replanted to corn in spring.

Cutworms entering the corn-field from pastures or meadows adjoining, may be effectively and cheaply poisoned by placing along the edges of the field fresh clover or other succulent vegetation which has been cut after spraying thoroughly with Paris green stirred up in water at the rate of a pound to fifty gallons.

The sixteen species whose names are placed at the head of this section have all been found injuring corn—only the first nine of them, however, notably harmful to that crop in Illinois.

THE GLASSY CUTWORM.

Hadena devastatrix Brace.

This is a translucent, whitish caterpillar (Fig. 1), slightly tinted with bluish green, without body spots or blotches, the head red or red-brown, and the neck-shield brownish. Its appearance has been quite aptly characterized as midway between that of a white grub and a common cutworm. It is quite similar to the yellow-headed cutworm next described, from which it is most readily distinguished by its darker head and neck-shield, and the lighter color of its body.

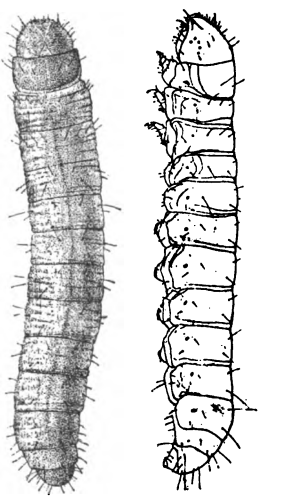

FIG. 1. The Glassy Cutworm (*Hadena devastatrix*), back and side views. Enlarged.

In view of the destructive nature of its attacks, its wide-spread range and great abundance, and the numerous published reports of serious injury to crops, this cutworm may be properly regarded as the most serious pest of its kind to corn and grass. It is rarely seen above ground, but works mainly in a burrow beneath the surface, feeding principally at night, eating off the roots close to the base of the stem, or cutting off the latter under ground.

We have found it very destructive to corn in Peoria and Henry counties, and frequently occurring in corn hills in various parts of the state. A. J. Cook reports it as injurious to corn in Michigan; Lintner, in New York; and Harvey, in Maine. Gillette pronounces it the most abundant and destructive cutworm in corn and grass in Iowa; Smith reports it as one of the most destructive of its kind in New Jersey; and Fletcher finds it injurious in Manitoba. It frequently becomes so numerous in meadows as to be notably injurious to grass. In

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Ohio, for example, twenty acres out of thirty of a timothy meadow were so injured by this cutworm that the grass became dry enough to burn. In mixed fields of timothy and clover they have completely destroyed the timothy, leaving the clover unharmed. In Indiana a large area in each of three timothy fields, amounting to fifty acres in all, was totally destroyed. There was an evident migration of the cutworms in this case out of the low lands in which they originated. They have destroyed lawns in Fargo, North Dakota, and in Glencoe, near Chicago. In Canada it was found necessary to plow up several fields of winter wheat which were destroyed by them in spring, and fields of oats were seriously injured and replanted. A piece of sod land in Ohio badly infested by these cutworms was broken up in winter and planted to seedling peaches, but in the following spring thirty-five per cent. of these young trees were cut off two or three inches above the roots. Lugger says that they are very destructive to strawberry plants in Minnesota, cutting away the crown and causing the plant to wilt away. They have also injured strawberry plants in the Southern States and garden vegetables in Mississippi.

FIG. 2. The Glassy Cutworm (*Hadena devastatrix*), adult. Natural size.

Besides these farm crops they may feed upon almost any kind of herbaceous plants, including cabbages, beans, radishes, hollyhocks, and lettuce. They evidently develop mainly in grass-lands, especially in low ground, and do their most serious injuries to crops following upon grass.

The species is found in the United States from the Atlantic to the Pacific, and also in Canada and in Europe. It is least abundant in the extreme South.

It appears to be single-brooded. The eggs are laid in the latter part of the season, mostly, according to Gillette, after August 1, and hatch before cold weather, the larvæ making their destructive attack in the latitude of central Illinois in the following May and the first half of June. They change to the pupa in the ground in June or the early part of July, occasionally as late as August. The moths (Fig. 2) begin to appear in June, become very abundant in August, and may remain until October. Garman found, November 25, a single cutworm of this species, which reached the moth stage the following April.

From this it follows that grass-lands must be plowed in August if they are to remain free from the eggs of this cutworm moth, and that corn planted late in June will probably remain uninjured by the cutworm itself.

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THE YELLOW-HEADED CUTWORM.

Hadena arctica Boisd.

It is very similar in appearance to the glassy cutworm just described, but may be distinguished by the fact that its body is pale smoky gray, while the head and neck-shield are both tawny yellow. It is without stripes, spots, or other body colors. It is so similar to the preceding species that it has often been confused with it, and it is consequently impossible to separate published statements concerning injuries due to the two. It lives usually about two inches under ground, cutting off the roots of grasses, grains, and corn, and the stems below the surface.

It is frequent, but not very common, in Illinois, and is widely distributed northward in Canada, Labrador, Vancouver, and in subarctic America and Europe generally. It occurs as far south as New Mexico, and is generally wide-spread east of the Rocky Mountains. In 1895 the moths were so abundant in western Ontario as to be a general nuisance, filling lamps and windows, and soiling curtains and clothes. In the following season these cutworms did great damage to fields of oats, wheat, and corn, many of the fields being plowed up and replanted. Cook has also found it injurious to corn in Michigan. In New York, Fitch observed that these cutworms would finish first any living grass remaining in the corn-field, but would then attack the crop itself.

Besides grasses and cereal crops, they feed on various herbaceous plants, such as cabbage, spinach, and lettuce, and on succulent shoots, like those of roses and currants.

This cutworm lives longer in the stage of destructive activity than many of the other species, often continuing its injuries beyond the middle of June, and even into July. It pupates in June or July, and the moths begin to appear late in June, becoming commonest in July and early August and lasting until September. Eggs have been deposited as early as June 13.

THE GREASY CUTWORM.

Agrotis ypsilon Rott.

This is a common, wide-spread, and destructive cutworm, injurious to garden vegetables and to fruits as well as to corn. When full grown (Fig. 3) it is about an inch and a half in length, of an almost uniform dark, greasy gray, with a faint dorsal stripe of dull, dirty yellow. Beneath, it is an obscure greenish yellow.

This is a typical cutworm in its feeding habits, and is one of the commonest of its kind in corn. It feeds also on grass, asparagus, cotton, tobacco, tomato, cabbage, potato, spinach, squash, beans, beets,

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apple, grape, and strawberries, but has not been reported as injurious to clover or as breeding in fields of that crop.

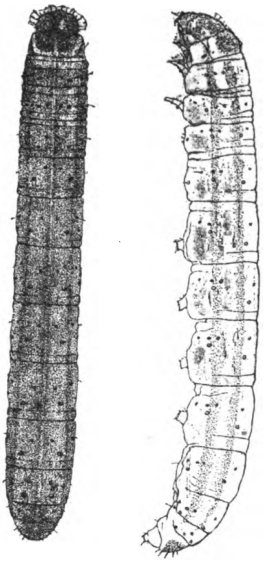

FIG. 3. The Greasy Cutworm (*Agrotis ypsilon*), back and side views. Enlarged.

It is found throughout the United States, and, indeed, throughout the world, ranging to the northward as far as Manitoba and Hudson Bay, to the south as far as Uruguay and New Zealand, and the Cape of Good Hope in Africa. It occurs in India, Ceylon, and China, and is a common European species also.

While destructively abundant at times and in especially favorable situations, it is not, so far as we know, subject to periods of very extraordinary increase. It is much parasitized, when abundant, by dipterous and hymenopterous parasites, and these must serve as a severe and ready check upon its multiplication.

This cutworm is apparently, but not certainly, single-brooded. It passes the winter mainly as a caterpillar, in various stages of growth; begins to feed, of course, as soon as spring revives it, and continues more or less injurious well through June, and sometimes even into July. The destructive activity of this cutworm usually reaches its height in the latter half of May and in early June, and then declines gradually through the first half of July. A few of the larvæ cease feeding, however, in May, and complete their changes to the adult stage (Fig. 4) during that month, but the transformations of the greater part of the hibernating generation occur in June. Egg-laying begins, according to our observations, in July, the new generation sometimes beginning to hatch in the grass within a fortnight of the disappearance of the last of the cutworms of the preceding year. This species may consequently be found in the cutworm stage at practically all times and seasons. Pupæ found in our breeding-cages on the 8th of June gave the moths in four weeks, and eggs laid July 3 hatched in twenty-two days.

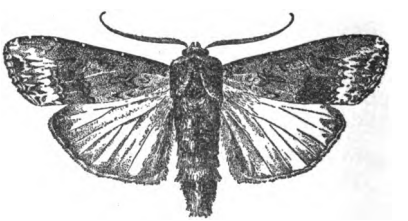

FIG. 4. The Greasy Cutworm (*Agrotis ypsilon*), adult. Natural size.

Beginning early in July, the laying of eggs doubtless continues through August, and possibly into September also. The moths have been most frequently found by us in July and August, with only occa-

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sional occurrences in September, the latest on our notes for central Illinois being September 20.

Breeding almost wholly in grass-lands, its injuries to corn are to be apprehended only where this crop follows upon grass, or where the corn-field adjoins a pasture or meadow. In the former case the injury may be generally distributed throughout the field, but in the latter it will be limited chiefly to the side next to grass. It continues its injuries so late in spring that it is difficult for the corn-grower to escape it by late planting, and even the first replanting of injured fields may fall a sacrifice to it; but plantings made as late as the first or second week in June will be practically safe from serious injury by it. On the other hand, the early date at which the moth begins to lay her eggs lessens the value of fall plowing as a preventive measure. Probably pasturing of infested fields of grass by pigs in fall, before breaking up for corn, is the best general preventive measure available in ordinary practice.

THE VARIEGATED CUTWORM.

Peridroma margaritosa saucia Hübn.

(*Agrotis saucia.*)

This cutworm, when fully grown, is about an inch and three-quarters long, and is easily recognized by its conspicuous markings. (Fig. 5, *b*, *c*, *d*, Fig. 6.) The general effect of its ground-color is grayish or brownish—usually variable, however, being light or dark as its surroundings expose it more or less to the light, those on trees or bushes being darker than those feeding near the ground on broad-leaved herbs. It is most easily distinguished, when of average color, by a row of four to six pale dots extending from the neck half way or more down the back, and a velvety spot on the segment next to the last, sharply defined behind, but shading gradually forward into the dark

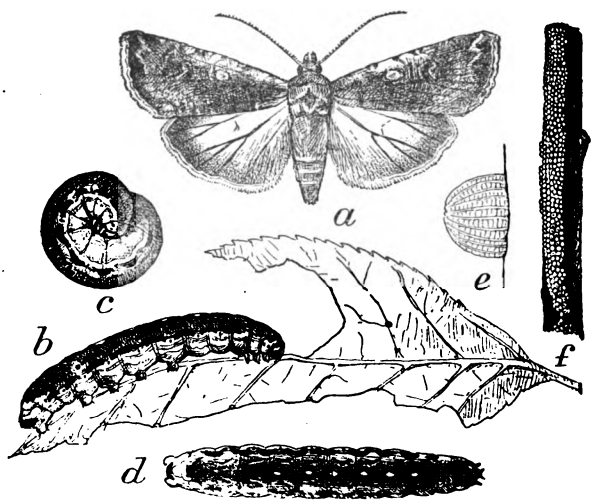

FIG. 5. The Variegated Cutworm (*Peridroma margaritosa saucia*): *a*, adult; *b*, *c*, *d*, larvæ; *e*, *f*, eggs. Figure *e* greatly enlarged; others natural size. (Howard, U. S. Dept. of Agriculture.)

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ground-color of the back. The freshly hatched caterpillars are greenish, with black heads.

This is a very common species, but is peculiar in its habits. It climbs plants freely at night to feed, even ascending bushes and fruit-trees, and devouring any succulent tissue which it finds, including bud, fruit, flower, leaf, stalk, or root of the plant. It occurs frequently in corn-fields, although not ordinarily common there. When very abundant it sometimes migrates in hordes like the army-worm, in search of food, and under such circumstances has been known to destroy hundreds of acres of young corn in a comparatively short time. It is pre-eminently a garden pest, however, being particularly destructive to fruits, vegetables, and flowers rather than to grain crops, weeds, and wild plants. A remarkable outbreak of this cutworm occurred in the year 1900 in the United States and Canada, especially in the states of the Pacific coast. Enormous damage was done by it, particularly to fruit and vegetable crops. A full account of this occurrence will be found in Bulletin 29, N. S., U. S. Division of Entomology, and in Bulletin 47 of the Experiment Station of Washington state. Among its leading food plants are cabbage, tomatoes, potatoes, clover, onions, peas, beets, and carnations.

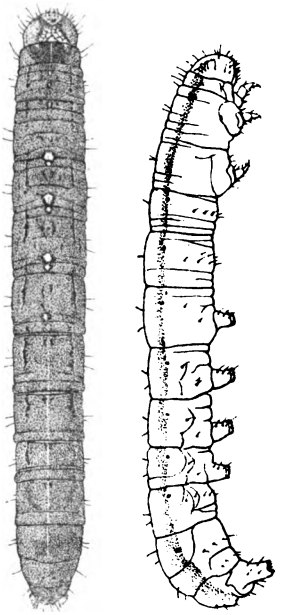

FIG. 6. The Variegated Cutworm (*Peridroma margaritosa saucia*), back and side views. Enlarged.

It occurs throughout nearly the whole of the New World, and also in western and southern Europe, northern Africa, and Asia Minor.

The seasonal history of this species is not yet well understood. It has been seen in winter as larva, as pupa, and as adult, and entomologists differ, consequently, in their statements as to its normal hibernating stage and the number of its broods. It agrees with most of the species, however, in the fact that it is destructively active in early spring, becoming most injurious in May and early June, pupating in June, and beginning to produce moths (Fig. 5, *a*) abundantly in the latter part of that month. The data which we have, suggest at least two broods in a year, but there is nothing conclusive upon that point. Eggs (Fig. 5, *e*, *f*) of this species were sent to us March 27 on an apple twig from Vandalia, and others were sent us April 17 from Hardin county, in southern Illinois, which were just hatching when received. The young cutworms were kept on clover until May 26, by which time they had reached an average length of about one inch, being, in other words, at this date some-

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what more than half grown. Female moths, on the other hand, confined in a breeding-cage with blue-grass July 10, had given origin six days later to freshly hatched larvæ, with which the cage was swarming at the time. Unfortunately, these presently died—probably because the food plant offered them was unsuitable. Other entomologists have several times secured and hatched the eggs of this species in the latter half of the season. In 1900, cutworms of this species—probably of the second brood—began to appear early in July, reached their greatest abundance about July 25, and had disappeared by the end of the following month. The advent of winter commonly finds individuals in every stage of growth, and moths, larvæ, and doubtless pupæ also may pass the winter successfully. We once found four larvæ in early December under boards and weeds in grass and corn. Two of these were about a third of an inch in length, and the others were approximately an inch and a quarter. Two full-grown larvæ were also found January 14 and 24.

Fortunately, this cutworm is not ordinarily sufficiently injurious in corn-fields to require special precautions except when it moves in companies from its breeding grounds, and then it may be dealt with like the army-worm, by measures to be described in the article on that species.

THE SPOTTED CUTWORM.

Noctua c-nigrum Linn.

The spotted cutworm is a common species, injurious in Europe as well as in America, especially to garden vegetables, which it seems to prefer to grasses and grains. It has occasionally injured Indian corn in various states, and, like the species just discussed, is liable to travel in companies when it becomes very numerous. Under these circumstances it might require the especial attention of the corn-grower. It is on record also as injuring wheat in January and in March. (Webster.)

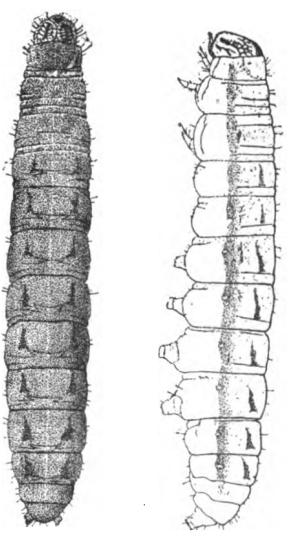

FIG. 7. The Spotted Cutworm (*Noctua c-nigrum*), back and side views. Enlarged.

It may be recognized (Fig. 7) by two rows of triangular black spots, one on each side of the back, with the narrow angle to the front, largest and darkest on the posterior segments of the body, and fading out before they reach the head. The general color of the caterpillar is pale brownish or ashy gray, and it is about an inch and a half long when of full size.

It hibernates as a cutworm nearly full grown, and pupates quite early, in central Illinois late in April and early in May; consequently, if injuries to corn are due

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to this species they will soon cease, and the first replanting will commonly escape unharmed. Moths (Fig. 8) from pupæ formed in April and early May have appeared in our breeding experiments during the latter part of May and the first half of June, and, proceeding without much delay to deposit their eggs, they gave origin to a second brood of cutworms which became fairly well grown about the middle of July. This generation is not often found in the corn-field, and does no injury there worth noticing. The moths from this second brood have appeared in our breeding-cages from late July to the middle of August. They continue alive in the fields throughout September, and lay their eggs in grass for the hibernating brood of the cutworms.

FIG. 8. The Spotted Cutworm (*Noctua c-nigrum*), adult Natural size.

Early fall plowing of infested grass-lands may thus be expected to take effect on this cutworm by preventing the laying of many of the eggs, and by causing the starvation of many of the young which may already have hatched.

THE DINGY CUTWORM.

Feltia subgothica Haw.

THE WESTERN STRIPED CUTWORM.

Feltia jaculifera Guen.

(*Agrotis tricosa, A. herilis.*)

The dingy and the striped cutworms are remarkably alike in both appearance and habits, and may well be treated together. The former (Fig..9) is dingy gray, and easily recognized by the dusky band on each side of the back, obliquely notched on the inner border like the edge of a serrated leaf. The broad dorsal space between these bands is a buffy gray. There are also a well-marked light band along each side of the body, and dorsal and lateral pale lines rather feebly marked.

The western striped cutworm is very closely similar to the preceding, perhaps indistinguishable in the caterpillar stage. Riley says, indeed, that it is more dingy than *subgothica*, with less conspicuous lines, and with a more decided buff tint to the dorsal band. These differences are, however, within the range of ordinary variation, and the species can apparently be distinguished with cer-

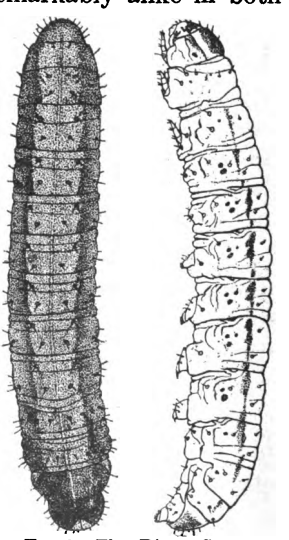

FIG. 9 The Dingy Cutworm (*Feltia subgothica*), back and side views Enlarged.

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tainty only by breeding to the adult. The young larvæ are much darker at first, sometimes nearly black.

The dingy cutworm is one of the commonest species, especially in corn, where it shares with the greasy cutworm the principal injury to that crop. Indeed, there is some reason to believe that the moth may lay her eggs in fall among the succulent weeds in the corn-field, particularly when a severe drouth has made the pasture and meadow lands less inviting. In accordance with this supposition these cutworms have not infrequently been found in early spring generally distributed through corn on old corn ground. Stedman speaks of it in Missouri as the most destructive cutworm in wheat. In our breeding-cages it has evidently preferred clover to blue-grass. It is especially fond of early vegetables, including melons, cabbage, tomatoes, beans, peas, sweet potatoes, turnips, lettuce, celery, and strawberry plants. It occasionally climbs fruit-trees and shrubs to devour their buds and leaves.

The striped cutworm is also decidedly destructive to corn, according to Webster, one field in Indiana being completely ruined by it in 1895. Similar injuries were noticed in the same year in Missouri, Kentucky, Tennessee, and southern Ohio. It was the most abundant cutworm in southern Illinois in the outbreak of 1887, and, next to *gladiaria*, the commonest and most destructive throughout the state during that of 1888. It did much harm to corn in these years, but was especially injurious to clover, for which it had an evident preference, and to the meadow-grasses. It frequently migrates when abundant in search of food, but without the concerted movement of the true army-worm.

Both of these species are generally distributed throughout the United States and Canada east of the Rocky Mountains. The dingy cutworm is also found on the Pacific coast, and we have specimens of the moth from Montana, Wyoming, and Utah. The striped species occurs in British Columbia.

There is but one brood of the dingy cutworm each year. Moths have been taken throughout July, August, and September, but much the most abundantly in the latter part of August. Eggs are quickly deposited, and hatch in about a week. The caterpillars grow slowly, and hibernate when quite small. Those taken by us in January, February, and March averaged less than half an inch in length, but when warm weather comes they grow apace, and in May become nearly full grown. In June they cease feeding, mostly in the first half of the month, and enter the ground for pupation. A dingy cutworm kept under observation in my insectary from May 15, entered the ground June 16, and continued as a larva in its earthen cell until August. On the 12th of this month it was found to have changed to the pupa, and on the 28th it became an adult. This long-delayed pupation was not due to drouth, as the earth in the breeding-cage was kept moist, and even wet. Besides

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the above we have found larvæ of different lots in a similar condition in our breeding-cages June 15, July 2, 19, and 23, and August 3. These facts indicate an unusually long period of midsummer preparation for the pupal transformation.

This life history suggests nothing exceptional by way of prevention or remedy. Where the field has become infested in fall, as shown by the general distribution of the cutworms in the corn in early spring, replanting, to be safe, should be postponed until towards the middle of June.

THE CLAY-BACKED CUTWORM.

Feltia gladiaria Morr.

This cutworm (Fig. 10) is usually dark in average color, varying, however, from greenish gray to dark brown. The back is commonly decidedly light, grayish white or straw color, or occasionally reddish brown. This light dorsal space is divided lengthwise by a more or less conspicuous median white line, which is usually bordered with darker. On each side of the pale dorsal space are two irregular whitish lines. The full-grown larva is about an inch and a quarter in length.

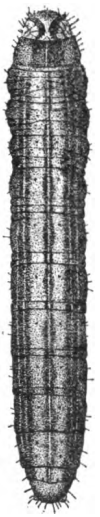

FIG. 10. The Clay-backed Cutworm (*Feltia gladiaria*). Enlarged.

This species is extremely variable in numbers, multiplying under some conditions to become a notable and widely destructive pest, and then occurring in scarcely noticeable numbers for some years thereafter. It was not distinguished as a cutworm until 1888, when it was bred to the adult in our insectary. In 1887 and 1888 it was the most destructive cutworm in Illinois, especially to clover and young corn. In 1895 it was by far the leading species in a general cutworm outbreak in Kentucky, and caused serious injury to a thirty-acre field of young corn on old sod ground near Champaign. In 1901 it was one of the most abundant cutworms in corn-fields in western Illinois, and was excessively abundant in pansy beds at Urbana, cutting off and destroying all the plants. During its years of greatest abundance here it was especially notorious for its injuries to clover, which it preferred to blue-grass. It likewise ate oats, grass, and corn, invading corn-fields from adjacent meadows, and devouring the plants as it went as thoroughly as does the army-worm.

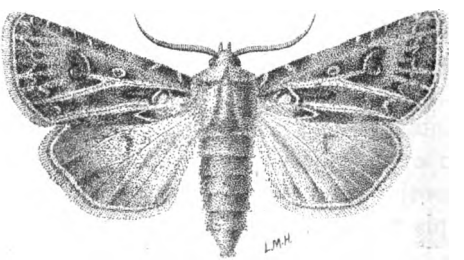

FIG. 11. The Clay-backed Cutworm (*Feltia gladiaria*), adult. Enlarged.

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It fed likewise on potatoes, beans, sweet potatoes, cabbage, tomatoes, and onions. When very abundant and their food supply had run short, these cutworms scattered in all directions—a habit common in varying degrees to most of the cutworms. Its mode of feeding is different from that of the cutworms generally, the corn leaf being seized by the hanging tip, drawn down, and eaten to the base. In clover fields, it begins at the tip of the plant and works downward, collecting about the roots.

This species is registered as inhabiting the United States east of the Rocky Mountains, but we have specimens of the adult from Utah and Colorado also.

It spends the winter, in our latitude, in the caterpillar stage, and is active in the destruction of its food plants from the middle of April to the beginning of June. By the middle of June all the cutworms have entered the earth for transformation. They do not change forthwith to the pupa stage, but remain there for a considerable period—more than six weeks in some cases—in a dormant or torpid condition. Moths (Fig. 11) consequently do not appear until September and early October, being most numerous in the latter half of September. Eggs are then laid without delay, and from these the larvæ hatch, which pass the winter partly grown.

It follows from this life history that the main measure for the protection of corn against this cutworm must be an impassable furrow along the margin of the field next to grass or clover, or, in the absence of this, the distribution of poisoned food—clover particularly—where the cutworms are likely to be drawn to it. Owing to the lateness of the period when the eggs are laid, a reasonably early fall plowing will prevent the breeding of the species on that ground.

THE BRONZE CUTWORM.

Nephelodes minians Guen.

This is an unusually large and plump cutworm (Fig. 12) about an inch and three-quarters in length, conspicuously marked with alternate stripes of olive-bronze and yellowish, the former much the broader. A pale stripe runs along the middle of the back, and there are two such on each side, the lower below the spiracles. The bronze space immediately above the last is frequently divided lengthwise by a delicate, broken yellow line. The head is yellowish or gray, the neck-shield darker, with five pale stripes.

This is essentially a grass cutworm, being one of the commonest of its kind in grass-lands in early spring. It is somewhat injurious to corn, especially if this is planted on pasture or meadow-lands occupied by it the preceding year. It eats clover sparingly or not at all, but seems to have a special preference for timothy. In the corn-field it devours the

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whole plant instead of merely gnawing through the stem. It is not a garden species, although it sometimes climbs fruit-trees when its normal food is scarce, feeding on the buds and leaves like other so-called climbing cutworms.

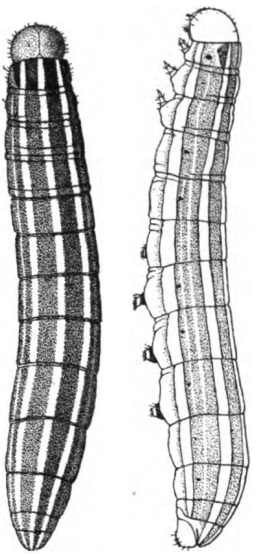

FIG. 12. The Bronze Cutworm (*Nephelodes minians*), back and side views. Enlarged.

It is generally common and abundant throughout the United States and Canada. In Iowa it is regarded by Gillette as the most abundant species, next to the glassy cutworm, in fields of grass and corn. It did much injury to grass in New York in 1881, and worked unprecedented destruction in 1886 near Columbus, Ohio, where, late in May, scarcely an acre of meadow or pasture had a vestige of grass on it for a distance of several miles, many fields being dry enough to burn. About three thousand acres were thus destroyed, the larvæ migrating *en masse* when their food was exhausted.

Hibernating in our latitude in the larval stage, they are found active in grass-lands in April and throughout May. They begin to disappear about the 1st of June, and all are gone by about the middle of that month. They remain under ground for a considerable period without pupating, changing in late July and August. The moths (Fig. 13) first appear in early August, become most abundant during the first half of September, and continue into October. The hibernating caterpillars have the singular habit of sometimes coming forth in winter and crawling about on the snow and ice. In the South, adults are frequently taken during the winter months.

FIG. 13. The Bronze Cutworm (*Nephelodes minians*), adult. Natural size.

This cutworm is present in very unequal numbers year after year, what seems to be a bacterial disease checking its increase when it becomes unusually abundant. On this account, and also because much subject to insect parasitism, it is not likely to be excessively abundant in the same locality for two successive years.

The facts concerning it suggest no special preventive or remedial measures other than those frequently referred to in this article. Where it is so abundant in grass-lands as to threaten a migratory movement, this may be arrested by measures usually applied against the army-worm. In case it scatters into corn from adjacent fields of grass, it may doubtless be killed by the use of poisoned food, particularly the mixture

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of middlings and Paris green. In case corn is so injured by it as to require replanting, this may be safely done any time after the first of June, or possibly as early as the last week in May. To be sure that a grass sod shall be virtually free from the eggs, this should be plowed as early as the first week in September.

HADENA LIGNICOLOR GUEN.

This cutworm closely resembles the glassy cutworm, but has never been fully described in the caterpillar stage. We have not found it common in Illinois, but have collected the moths during June, July, and August. Gillette reports that the moths are very common in Iowa. They are found generally in the northern part of the United States east of the Rocky Mountains, and have been reported from Arizona.

A cutworm of this species which was found by Lintner preparing for pupation May 18, completed its transformations and came out as a moth on the 29th of June. Females dissected by Gillette July 13, were well filled with eggs.

These facts indicate a comparatively early close of active life as a cutworm, and a comparatively early appearance of the adult moth.

THE W-MARKED CUTWORM.

Noctua clandestina Harr.

This caterpillar (Fig. 14) is marked with four longitudinal rows of dark spots and some dark and pale longitudinal lines. The spots of the outer row on each side are oblique, and sometimes unite to form a continuous line; those on the inner row are more or less triangular (most evidently so on the hinder segments), and occasionally have the shape of the letter W.

This is a very wide-spread species and a general feeder, but is ordinarily much more abundant in the East than in the north-central states. It is not found in the South. Dr. Lintner regards it as the most injurious corn cutworm in New York, where it is said to be common also on grass and grain, and to feed on buckwheat and clover. It is fond of garden vegetables, and feeds on lettuce, cabbage, celery, pumpkins, and beans. It is a well-known climbing cutworm, ascending trees and shrubs to eat the buds and leaves, particularly those of the apple, box-elder, soft maple, currant, and gooseberry. Plantain is mentioned as one of its wild food-plants.

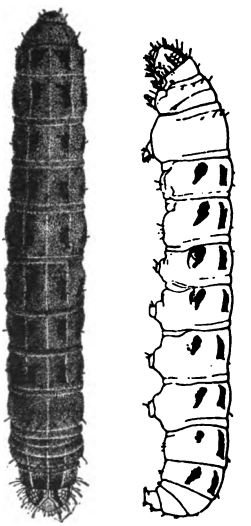

FIG. 14. The W-marked Cutworm (*Noctua clandestina*), back and side views. Enlarged.

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The larvæ winter over about half grown, and mature early, becoming most injurious in April and May. The moths begin to appear soon thereafter, and are most abundant about June 20. The data on record indicate a probable second brood of the cutworms in midsummer, the moths appearing in August, September, and October.

The early transformation of the hibernating brood renders precautions against this cutworm virtually unnecessary, since it can injure only very early plantings of corn.

THE GRANULATED CUTWORM.

Feltia annexa Tr.

This species is best known by its rough, granulated skin, and by a pair of oblique marks on each segment, diverging backward. (Fig. 15, *a*, *e*.)

It is a general feeder, devouring corn, wheat, and other cereals, cotton, clover, grass, cabbage, peas, beans, and several weeds. It is particularly well known in the Southern States as a cotton cutworm, sometimes so badly injuring this crop as to compel replanting.

It is not common in Illinois, but is found, nevertheless, across the country from Massachusetts to California, and is abundant from Kentucky southward, and also in Cuba and South America. Lugger records a single capture in Minnesota.

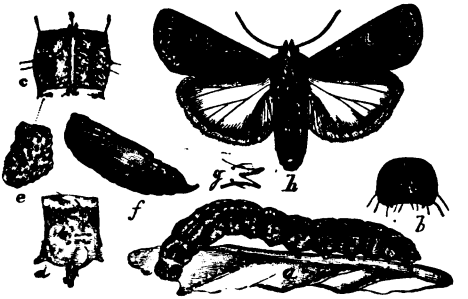

FIG. 15. The Granulated Cutworm (*Feltia annexa*); *a*, larva; *b*, its head, front view; *c*, *d*, one segment, top and side view; *e*, surface; *f*, pupa; *g*, tip of pupa; *h*, adult. Figures *a*, *f*, *h*, natural size, others enlarged. (Howard, U. S. Dept. of Agriculture.

The facts with regard to its seasonal history have not yet been clearly established. It seems to winter as a larva, and is most destructive in April and May. Moths (Fig. 15, *h*) of this brood appear in June, July, and August. From eggs laid August 3, moths were reared again by October. Beutenmüller says a second brood flies in August, September, and October. There are almost certainly two generations in a year in Illinois, and quite likely three, or more, in the Gulf States.

THE DARK-SIDED CUTWORM.

Euxoa messoria Harr.

The common name of this cutworm (Fig. 16, *a*) is due to the contrast of a dark stripe on each side with the ashy gray ground-color. The small shining spots surrounding the hairs are conspicuous and black.

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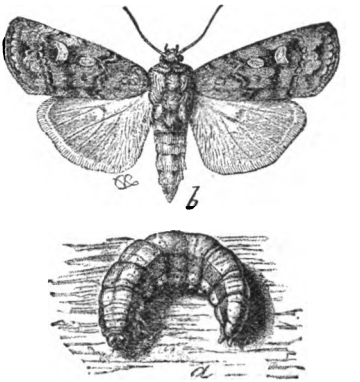

FIG. 16. The Dark-sided Cutworm (*Euxoa messoria*), larva and adult. Natural size.

Although one of the great destructive cutworms of the United States, this species is not reported as particularly injurious to corn. It is one of the climbing cutworms, and its most notorious injuries are done to fruits and garden vegetables. It is charged with a great destruction of the peach crop in Illinois, Indiana, and Michigan in 1887, and with devouring about half the onion crop of Orange, N. J., in 1885 and 1887, and again in 1896. In California it was held responsible in large part for the defoliation of grapevines in Fresno county. Smith speaks of it as the most injurious cutworm in southern New Jersey, especially to sweet potatoes. It ascends fruit-trees, the apple especially, and eats the buds of both flowers and leaves. It feeds, besides, on cabbage, spinach, lettuce, potatoes, tomatoes, beans, peas, radishes, turnips, tobacco, and sugar-beets. Specimens in confinement have freely eaten grass, corn, clover, buckwheat, currant, soft maple leaves, and various fleshy weeds. Indeed, it is so general a feeder, Gillette remarks, that in confinement it has not refused to eat any green thing offered it.

This species is not particularly common in Illinois, and has been rather infrequent in our collections either as caterpillar or as moth. It has been reported injurious, however, from New York to California and Washington state, and northward into Canada. It seems to be comparatively rare to the southward.

It is evidently a single-brooded species, the caterpillars being most abundant in May and disappearing by the middle of June. Occasionally adults (Fig. 16, *b*) occur in the latter part of June, but the main body of them appear late in July, and are most abundant in September up to about the 20th. The stage of hibernation is not yet positively ascertained. Caterpillars, apparently of this species, were taken by me from the stomachs of robins shot in February and March, and the species probably hibernates in the larval stage.

Highly satisfactory experiments for the destruction of this species and the protection of garden crops have been made by Sirrine, in New York, who used a mixture of twenty or thirty pounds of middlings or bran—the former preferred—to one of Paris green. A continuous row of this poisoned bait was laid along the ground by means of a seed-drill.

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THE COMMON STRIPED CUTWORM.

Euxoa tessellata Harr.

About one and a fourth inches in length, gray in general color, with a pale central dorsal line and three pale lines each side, the lower one the broadest.

The recorded food plants of this cutworm are corn, potato, onion, tobacco, radish, squash, cabbage, lettuce, tomato, celery, spinach, beans, flax, cucumber, melon, beet, and parsnip, together with smartweed, *Rumex*, and various weeds, plum, apple, pear, and cherry. In confinement it feeds freely upon grass, clover, buckwheat, box-elder, and the fleshy weeds. It is not on record as especially injurious to corn, being evidently a garden species rather, and my own observations support this statement. Cook found it injuring corn in Michigan, and Fitch in New York, the latter treating it in his Ninth Report under the name of the corn cutworm.

It is essentially a northern species, very abundant in the northern United States and Canada, but less common in central Illinois and southward. The caterpillar hides in the earth by day, cuts off the plants by night about half an inch above ground (and not below the surface, as do the Hadenas), and drags the leaves into its hole to feed upon them during the day.

FIG. 17. The Common Striped Cutworm (*Euxoa tessellata*), adult.

There is but one brood a year, and the cutworms pass the winter about half-grown, becoming most destructive in the latter part of May and the first of June. The moths (Fig. 17) are most abundant early in July. They have been taken in Iowa from early June to the beginning of August, and in Canada during the latter half of July and all of the following month.

THE RED-BACKED CUTWORM.

Euxoa ochrogaster Guen.

This is a very well-marked species, the caterpillar quite large, more than an inch and a half long, gray or dull brown, with a broad sienna-red stripe down the middle of the back.

It is a Canada cutworm especially, ranging from Prince Edward Island to British Columbia, and often excessively abundant in that latitude. It is less abundant in the northern United States, and is not reported from localities farther south than Missouri, Colorado, and California.

It is regarded by Fletcher as the worst corn pest among the Canadian cutworms. It is also particularly troublesome in gardens, attacking all garden vegetables and flowering annuals. It has not been found by us

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in corn in Illinois, and is, so far as our observations go, scarcely to be regarded as an economic species in this state.

The larvæ are present in the field through May and June, and sometimes into the following month. The moths occur in the latter part of June and in July and August, with scattering examples continuing into October. There is apparently but one brood a year.

THE BRISTLY CUTWORM.

Mamestra renigera Steph.

This is a small yellowish gray species (Fig. 18) about an inch in average length when full grown, marked by two blackish stripes, one on each side, with an unusually broad pale dorsal area between them. There are other less conspicuous stripes and lines, and the hairs are coarse and long, giving the caterpillar a bristly appearance.

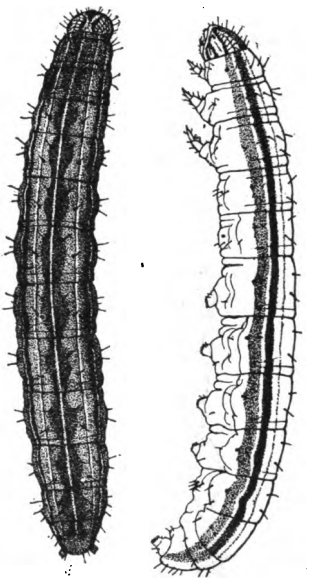

FIG. 18. The Bristly Cutworm (*Mamestra renigera*), back and side views. Enlarged.

This abundant little cutworm has been occasionally found by us at the base of injured corn plants, but it is mainly a grass and garden species, the spring brood of the caterpillars getting their growth too early to injure corn materially. It feeds mainly on the roots of its food plants, especially on garden flowers. The food plants listed are clover, the common grasses, chicory, turnips, and comfrey, to which we add corn and cabbage. Gillette reared specimens on cottonwood leaves and alfalfa.

This species is found from Canada to Georgia, Colorado, and New Mexico, and it has been reported as very abundant in Iowa, Illinois, Ohio, and New York.

There are two generations each year, one of which hibernates as a cutworm partially grown. We have taken young larvæ at frequent intervals from December 2 to April. Injury to crops by this species is most serious in central Illinois in the latter part of April and early in May. The cutworms pupate during May, and the moths (Fig. 19) appear in the latter part of that month, continuing common until the middle of July. Representatives of the second brood of cutworms have been found in early August, and the second brood of moths begins to appear late in that month, and continues through September and into early October. In Kentucky the

FIG. 19. The Bristly Cutworm (*Mamestra renigera*), adult. Enlarged.

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first generation of the moths was reported present from April until after the middle of June, and the second generation in August and September. In Iowa the moths are said to be most abundant in June, and again about the end of August. In Canada the first generation begins to appear late in June.

THE SOD WEB-WORMS, OR ROOT WEB-WORMS.

SEVERAL SPECIES OF CRAMBUS.

Every observer of insect life has noticed, as he walks through grass on lawns or meadows in summer, multitudes of small white or grayish moths (Fig. 21, 23) rising before him, flying a short distance, and then lighting to rest on the grass, head downward, with the body parallel to the blade. These moths, or millers, if examined when at rest, are seen to have the wings folded around the body in a way to give them a cylindrical form instead of the usual triangular one of ordinary moths. These are the parent insects of small, slightly bristly, reddish caterpillars which live abundantly in the turf, hidden away by day in a silk-lined burrow among the roots of the grass, but becoming active at night, when they feed especially upon the underground part of the stem of the plant, sometimes also upon its roots or blades.

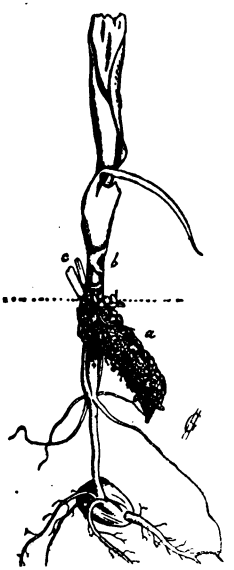

FIG. 20. The Sod Web-worm (*Crambus*): web (*a*) containing larva, at base of young corn plant; *b*, *c*, injuries to leaf and stem

General Description.—These caterpillars (Fig. 20, 22) average about half an inch in length when full grown, are pinkish red or brownish, and covered with rows of comparatively smooth dark spots, from the center of each of which springs a rather coarse hair. They differ from cutworms in their habit of quickly wriggling away when picked up or disturbed, and making active efforts to escape. Cutworms, on the other hand, are sluggish, and take disturbance quietly, simply curling up and taking their chances.

Injuries.—Not infrequently the web-worms become so abundant as to cause brown or deadened spots in a lawn or meadow, sometimes, indeed, in seasons unfavorable to the growth of grass, deadening the turf as thoroughly as white grubs or cutworms can do. When land so infested is planted to corn, this plant is very likely to be heavily injured, or even completely destroyed over considerable areas in early spring. The injury done is somewhat like that due to cutworms, and is largely under ground, but, on the other hand, the stems are rarely completely severed until the whole plant is eaten up. Commonly the first injury to the plant is done by

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gnawing the outer surface beneath the ground and about the roots. Then the caterpillar works upward, eating a superficial furrow or burrowing lengthwise along the center of the stem. The leaves are also frequently eaten, the lower ones first, and then the upper ones. The tips are eaten off, or irregular elongate holes are eaten through the blades. The injury being done at night, search must be made for the author of it by day by digging around the affected hills. The web-worms will commonly be found just below the surface (Fig. 20, p. 371), each in a retreat formed by loosely webbing together a mass of dirt, more or less cylindrical in shape, an inch and a half to two inches long, and about half an inch through. Within this mass is a silk-lined tube opening at the surface of the ground next to a stalk of corn, and within this specially prepared domicile a single caterpillar is secreted. Injuries due to these web-worms are commonly attributed by farmers to cutworms, and the caterpillars themselves are similarly confounded. This error would signify but little except for a single important difference in the midsummer life history which has its bearing on the proper time of plowing the sod in spring, and that for planting or replanting the corn. Cutworms are never protected by an underground web, are much larger than web-worms, make no active efforts to escape when disturbed, but curl up and remain inactive, and are without rows of conspicuous shining spots upon the body, these being represented by small and inconspicuous ones.

The injury to corn by the sod web-worms is not uncommon in fields planted on sod ground, and as it begins quite early and may last some weeks, it is fully as serious as a similar attack by cutworms or white grubs. Frequently more or less extensive replanting is required, and sometimes whole fields are completely destroyed two or three times in succession. In Ohio, for example, hundreds of acres of corn and oats were as completely killed in 1895 as if burned over, and similar injuries to corn have been reported from New York, New Jersey, Delaware, Maryland, Illinois, Iowa, and Nebraska. In Illinois and Iowa it was a most serious corn pest in 1887, destroying corn on sod ground in many fields distributed through several counties in both these states; and in Pennsylvania it was found destructive to corn in 1891, most injurious here as elsewhere, in one case at least, on old timothy sod. Besides its occasional injuries to corn, and to small grain where this follows upon grass—a rare event, indeed, at least in Illinois—its principal injuries are to grass in meadows and pastures. Its injuries here are much greater than are commonly attributed to it. "This fact is due," says Dr. Felt, "to its very insidious methods of work."

"Unless the damage they do is very serious it is hardly noticed, or, if noticed, attributed to other causes. As the larvæ live a retired life, close to the surface, eating mostly at night and remaining in their nests

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during the day, they are rarely seen. Like most larvæ they feed most voraciously just as they are completing their growth; consequently, when the damage is noticed most of the larvæ are hidden in their retreats where they pupate. In these places none but an experienced entomologist would find them, or would think of associating the damage done with the harmless appearing moths that fly later.

"Hardly any farmer would think seriously of the loss of only one stalk of grass in ten, yet the aggregate for the country at large would be enormous. Not only is the damage to a crop where nothing short of a serious injury would attract attention, but the damage is distributed throughout the growing season. As a general rule, each species is most destructive at a different time from the other species of that locality; hence, species of *Crambus* prey upon the grass as a succession of small armies. Could the loss caused by these species come at one time in the year their destructive power would be better appreciated. Less than a third of the species may be classed as of economic importance, but these possess a capacity to cause almost infinite loss if the conditions are favorable."

Additional Examples of Injury. From Office Notes.—At Champaign, May 28, 1885, *Crambus* larvæ were injuring young corn by gnawing the outer leaves at the surface of the ground, and also by eating out irregular holes in the leaves and the blades themselves. Frequently the leaves were eaten off and lying on the ground or partly drawn into the mouth of the web. Occasionally a plant was gnawed completely through at the surface of the ground, as by a cutworm. The injury here was sufficient to cause a partial replanting of the field. This land had been in pasture for fifteen years, and no damage to the grass had been noticed. It was plowed about the 8th or 9th of May, and planting was finished May 15.

At Milan, in Rock Island county, August 13, 1885, farmers reported the presence of a worm which made a web at the roots of the corn and ate the leaves while young, after which it worked about the roots, cutting them off just below the surface of the ground. Seven acres of corn on sod were almost completely destroyed, only a hill here and there being left. These larvæ fed mostly in the evening and just after a shower. They had been seen traveling from one hill of corn to another.

At Mt. Pulaski, Logan county, Illinois, according to observations and statements made June 16, 1885, larvæ of *Crambus zeëllus* (= *luteolellus*) had so far injured a small field of eight acres of corn that it had been replanted about the last day of May. On the 16th of June the worms were still somewhat active, and corn plants were frequently seen which had been more or less injured by it. Many of the webs were vacant, however, the larvæ evidently having gone largely into the earth

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for pupation. This field had never been plowed until the preceding fall, when it was broken up for corn.

A field of corn near Philo, in Champaign county, Illinois, visited June 1, 1886, was found unevenly infested by this insect, one patch of about an acre being completely destroyed. This corn was on sod broken April 7 and planted May 7 and 8.

July 31, 1888, blue-grass was found entirely killed over large patches in a lawn at Urbana, Ill., by the larvæ of *C. trisectus*, and numerous webs, some of which still contained the larvæ, were exposed by clearing away the dead grass on the lawns. On one of these lawns, which ten days before had been thick and as soft as velvet, only a few small spots of green remained. It was spotted with tufts of dead grass pulled out by the birds, many species of which were evidently feeding freely on the web-worms. The larvæ, all nearly or quite full grown, were transforming rapidly at the date of this observation.

June 13, 1891, caterpillars of *trisectus* and *mutabilis* were found seriously injurious to forty acres of corn belonging to Mr. W. C. Baker, near Savoy, Champaign county, Illinois. At least two-thirds of the first planting of the forty-acre field had been destroyed, and much of the second planting also. This field had been in pasture for eight or nine years, and was plowed the preceding fall, at just what time my information does not indicate.

Another field, of eighty acres, adjoining the foregoing, also broken in fall, had suffered still more heavily, most of the first two plantings of corn being devoured, and about a third of the third planting also. The caterpillars were still somewhat active June 13, but most of them had ceased their feeding and deserted their webs. It is evident, consequently, that in this case the proper time for replanting would have been about June 10, and that corn planted at this time would have escaped serious injury.

In another field adjoining this, about a fifth of the corn had been destroyed on sod ground plowed in spring. This field had also been in pasture for several years.

At Knoxville and Oneida, in Knox county, Illinois, corn on sod ground examined May 25, 1901, was found damaged by the larvæ of *trisectus* and *vulgivagellus*, associated with ordinary cutworms, to the amount of twenty-five per cent.; and at Buda, in Bureau county, May 28, a field was visited, from fifty to seventy-five per cent. of which had been destroyed by the same web-worms and striped gophers, necessitating a second planting.

From Office Correspondence.—The following reports of injuries by the web-worms are from my office correspondence. All were verified by an examination of specimens.

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Galena, Jo Daviess County, Ill., May 23, 1887. I send a box containing worms which are very destructive to corn planted on spring-breaking. [This was *Crambus luteolellus*.]

Hoopeston, Vermilion County, Ill., August 2, 1888. About three weeks ago noticed that the blue-grass on my lawn was beginning to die in spots. Watering did no good. On examination I found worms, like those sent you to-day by mail, averaging one or more to the square inch. They cut off the blue-grass at the top of the ground, but do not disturb the timothy or white clover.

Payson, Adams County, Ill., May 21, 1886. I find a few of the corn root web-worms on a piece of clover sod plowed this spring and planted April 30 and May 1. I find them as often on clover growing in the field as in the hills of corn, and I think they may breed in the clover. The field was planted to corn in 1881 and 1882, sowed to wheat in the fall of that year and again the year following, sowed to clover in March, 1885, this being plowed up in the spring of 1886 and planted to corn.

Smithfield, Fulton County, Ill., May 31, 1887. I mail specimens of a worm that is cutting the corn planted on sod. They are likely to take the third planting, and are working some on stubble. [This was *Crambus trisectus*.]

Galesburg, Knox County, Ill., May 2, 1887. I send you a few grubs that have been eating up the sod corn. I find them on meadow plowed up last fall, also on meadow plowed this spring. They ate up nearly every hill of sod corn, but did not touch corn on old ground next to it. I replanted ten days ago. The new planting is now big enough to plow, and is all right as yet. [These larvæ belonged to *C. trisectus* and *C. mutabilis*.]

May 25. I learn that the corn on a large scope of country is injured in the same way as mine. One man is planting his sod corn to-day for the third time.

Eden, Peoria County, Ill., May 19, 1887. I send by this mail a box of worms found in a corn-field on our farm. The field was an old timothy meadow plowed this spring and planted about the 5th of May. They are taking the corn here very rapidly.

Randolph, McLean County, Ill., May 16, 1887. I send you a sample of worms destroying our corn. The land is timothy sod broken the first two weeks in April, and planted the first of May. It has been in meadow for five years. On a part of it considerable clover is growing from seed sown two years ago, and on this part the worms are not so bad. The rest of the corn is taken clean, eaten off just above the ground. We find the worms an inch deep in the ground, the dirt being stuck together. Some of them are very small; others are half an inch long. [*C. trisectus* and *C. mutabilis*.]

Hanover, Jo Daviess County, Ill., May 24, 1887. I inclose several specimens of worms which have done a great deal of damage to corn in this county this spring. The damage has been exclusively on sod ground, both fall and spring plowing suffering alike. From reports from different parts of this county I learn that the ravages of this worm are general throughout the county. The plant is attacked just at the surface of the ground, where the worm weaves a web to protect itself from ants and other enemies, and then the stalk is eaten downward. One piece of ten acres on rich black soil on my own farm I replanted entire on the 14th of May, and now the worms bid fair to destroy it entirely again. Hundreds of acres have been replanted in my own town, and the area of ground in the county damaged by this worm will reach into the thousand acres. [*C. luteolellus*.]

Hamlet, Mercer County, Ill., May 19, 1887. My corn is infested with a larva that is a stranger to me. This morning I collected a few of them, and put them in a box directed to you. They do their work at night above ground, and mostly on the upper part of the leaves, but often cut the stalk off at the base of the leaves.

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Their nest has its mouth close to the corn they are eating, but may run on the ground an inch before going down. It consists of a web case, to which the dirt adheres. They are doing their worst work on a piece of ground on which rye was grown last year. I often find two or three of them to a single hill of corn. They are mostly small, but I have found a few over an inch in length.

Glenwood, Cook County, Ill., June 15, 1888. I send you inclosed some cots which are supposed to belong to the web-worm. I broke up and planted to corn seventeen acres of timothy sod that had been seeded about twelve years, and I find these cots lying around on this ground. The cutworms are so plenty that they do not let the corn get much above ground.

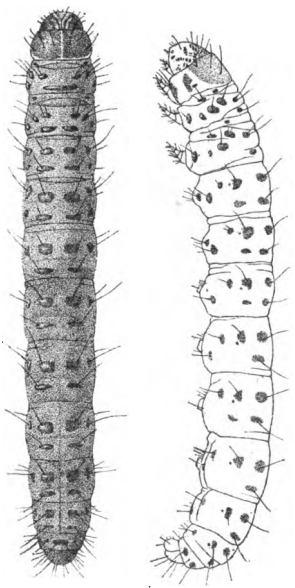

FIG. 20. The Common Sod Web-worm (*Crambus trisectus*), back and side views. Much enlarged.

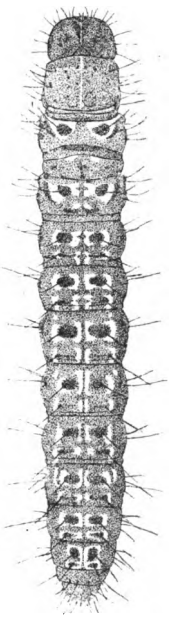

FIG. 22. The Striped Sod Web-worm (*Crambus mutabilis*). Much enlarged.

FIG. 21. The Common Sod Web-worm (*Crambus trisectus*), adult. Slightly enlarged.

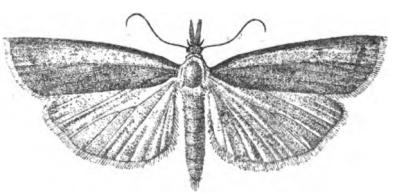

FIG. 23. The Striped Sod Web-worm (*Crambus mutabilis*), adult. Enlarged.

Four species have thus far been bred from corn, namely, *Crambus trisectus* Walker (Fig. 20, 21), *C. luteolellus* Clem., *C. mutabilis* Clem. (Fig. 22, 23), and *C. vulgivagellus* Clem.

Besides the injuries to corn, grass, and oats already mentioned, wheat

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and rye have been injured by *vulgivagellus*, tobacco by *luteolellus* (*caliginosellus*), and cranberry by *hortuellus*, a species not yet reported from corn.

There are about sixty species of the genus *Crambus* in the United States. So far as known they are of very similar habit, and it is quite likely that any of them living habitually on grass will injure corn if this is exposed to their attack. The species notably injurious to this crop will consequently depend, in all probability, upon those which happen to predominate in the grass at the time the field is plowed, and as these predominating species differ from year to year, the list above given is not to be regarded as final.

Distribution.—The recorded distribution of the four species actually bred from corn extends from the Atlantic to the Pacific, and from Maine, Canada, and California, to Texas, Louisiana, and Florida.

More specifically, the known distribution of the species with which we are here especially concerned is substantially as follows:

C. mutabilis, from Ontario, Massachusetts, Connecticut, and Dakota, to New York, Ohio, Illinois, Kentucky, Florida, Louisiana, Texas, Nebraska, and California.

C. trisectus, from Canada, Maine, Michigan, Minnesota, Dakota, Wyoming, and Vancouver, to New Jersey and New Mexico.

C. luteolellus,* from Maine, New York, Ontario, Minnesota, and Colorado, to North Carolina, Illinois, Texas, Arizona, and California.

C. vulgivagellus, from Maine, Massachusetts, New York, Canada, Wisconsin, and Vancouver, to North Carolina, Missouri, Colorado, Utah, and California.

Life History.—The biology of the species has not been sufficiently studied to give us a comparative knowledge of their life histories, although existing evidence indicates a difference in the species with respect to the number of annual generations, which varies from one to three in a season in the same locality. It is possible, however, that ampler data would remove this impression.

So far as known, all pass the winter in our latitude in the caterpillar stage, apparently not full grown. In early fall they close the mouths and thicken the walls of their cylindrical silk-lined nests before going into hibernation. In the spring they come forth, complete their growth, pupate near the surface, and later emerge as adults. "The eggs," says Dr. Felt, "are usually, if not always, allowed to fall at random in the grass. They hatch in from ten to twenty days." Eggs of various species have been obtained by us from June 9 (*trisectus*) to July 22

* A thorough study of authoritatively named adults, of the larvæ, and of the literature of the three so-called species *caliginosellus*, *zeælus*, and *luteolellus*, amply confirm previous conclusions of this office, that they represent only variations of a single polymorphic species, *luteolellus*. The details will be given in a later portion of this report dealing with the data of less economic importance relating to corn insects.

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(*hortuellus*), and these have hatched in from ten to fourteen days. Most of them were laid singly, but occasionally in clusters of five or six. When first laid they are nearly white, but they change with age to yellowish orange. The young caterpillars form their web-lined nests immediately upon or just under the surface of the soil, strengthening them by the addition of bits of grass or particles of dirt to the surface. They commonly cut off the blades of grass and draw the ends down into the nest so that they can feed without leaving it.

The data concerning the life histories of the various species are not sufficiently complete for all to warrant general comparative statements concerning them. It is certain that two of the species, *trisectus* and *mutabilis*, are at least two-brooded. A tabulation of the dates of collection of a very large series of adults made in several successive years, shows two well-marked periods of maximum occurrence, one in July and one in August, with a comparatively sparse showing towards the middle of July. Larvæ of *trisectus* have been found abundant in May and early June, and again in late July and early August. Those of *mutabilis* are commonest in the latter half of June. The fact that a third wave of abundance of the moths of *trisectus* was noted one year in early October suggests the possibility of a third brood of this species at least. *Vulgivagellus*, on the other hand, appears to be a single-brooded species. The larvæ mature late in May, but remain, as a rule, in their underground cells, like some cutworms, dormant through midsummer, emerging as adults in August and September. The eggs are then laid for the hibernating brood of the caterpillars, which will be found in young corn most abundantly during the latter part of May and early in June.

The data concerning *luteolellus* also indicate, so far as they go, a single brood, the moths appearing most abundantly in June and July, with only scattering occurrences in August, and none in the later months. Our breeding-cage results are likewise consistent with this supposition.

The points of especial economic interest in the life histories of these various species are virtually the same as in the case of cutworms. It is desirable to know at what time in fall the eggs are laid for the hibernating brood of caterpillars, since this will fix the time when grass-lands should be plowed as a preparation for corn-planting the following year. It is also desirable to know at what time in spring the hibernating caterpillars cease their work, and when eggs are laid for the next generation. The first of these dates fixes the time of planting or replanting corn on infested land, and the second determines when grass-lands may be plowed in spring to the best advantage if the sod was not broken up the preceding year.

Prevention and Remedy.—The facts concerning these web-worms all admonish the farmer to break up a grassy turf as early in the fall as

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practicable preliminary to planting the ground to corn; the middle of September is as late as safety permits. If, however, this is not done until spring, it may best be postponed, so far as web-worm injury is concerned, in most cases, until the latter part of May. If an infested meadow or pasture is plowed earlier than this, when the larvæ are still young, they will probably live to attack the corn when it appears; and if plowing is postponed later, until the first brood of moths have emerged, they are likely to lay their eggs in the grass before plowing, and thus to give origin to a brood of caterpillars which, being quite young when the corn comes up, will make a long-continued attack upon it, against which replanting will be of no avail.

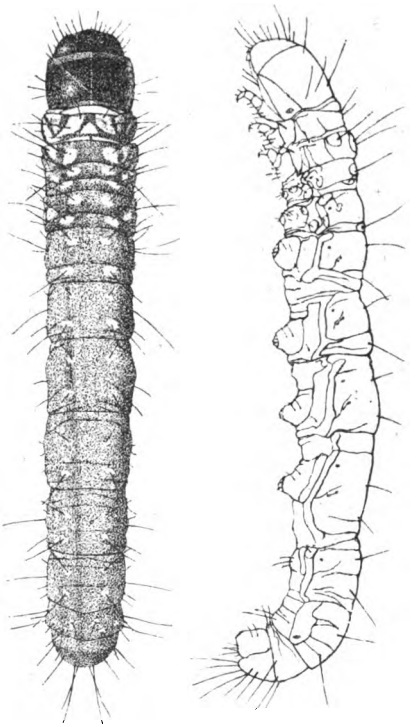

FIG. 24. A Burrowing Web-worm (*Pseudanaphora* or *Hypoclopus*), back and side views. Much enlarged.

THE BURROWING WEB-WORMS.

Anaphora popeanella Clem.
Pseudanaphora arcanella Clem.
Hypoclopus mortipennellus Grote.

These species, treated among the less important insects of the corn plant, are mentioned here merely to distinguish the larva of this group (Fig. 24) from the other web-worms, which it resembles somewhat in habit and injury to corn. It inhabits, however, a vertical cylindrical burrow penetrating the earth to a depth varying from six inches to two feet or even more. It is about the size of a common cutworm, but differs by its dull velvety surface and its colors, varying from silvery gray to brown, by the rows of polished spots on the body, and by its greater activity and more loosely jointed structure.

THE STALK-BORER.

Papaipema nitela Guen.
(*Hydræcia nitela, Gortyna nitela.*)

This well-known caterpillar, often called the "heart worm" because of the character of its injury to corn, may be at once known wherever it is seen by the peculiar break in the striping of the body at the mid-

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dle (Fig. 25, *b*). It is about an inch long when full grown. The general color varies from purplish brown to whitish brown, according to age, and it is marked with five white stripes, one running down the middle of the back, and two on each side. These side stripes are interrupted, being absent on the first four segments of the abdomen, giving the larva an appearance as if it had been pinched or injured there. The stripes nearly vanish as the larva matures (Fig. 25, *c*). The head and top of the neck, and the leathery anal-shield at the opposite end of the body are light reddish yellow, with a black stripe on each side.

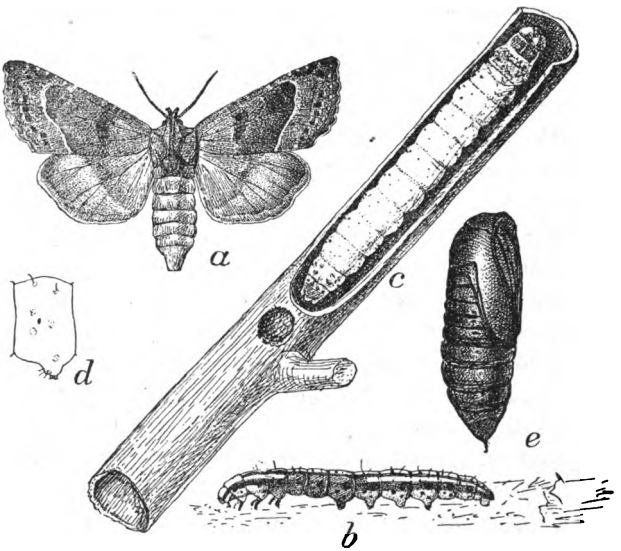

FIG. 25. The Stalk-borer (*Hydræcia nitela*): *a*, adult; *b*, half-grown larva; *c*, mature larva in burrow; *d*, side of one of its segments; *e*, pupa. All slightly enlarged. (Chittenden, U. S. Dept. of Agriculture.)

Its presence in a young stalk of corn is very clearly indicated by the wilting, breaking down, and death of the top, and by the presence of a round hole in the side of the stalk (Fig. 25, *c*), plugged with the brown excrement of the caterpillar within.

It infests a great variety of other plants in a precisely similar way. It is most noticeable in early spring in blue-grass, by roadsides, or around the borders of a field, its presence there being betrayed by the whitening of single heads of the grass while all the rest of the plant is green. At this time it is of small size, and finds sufficient food within the grass stem; but later it is compelled to resort to thicker-stemmed plants, and it is at this time that it may appear in fields of corn.

Going in usually from outside the field, its injury is, as a rule, almost wholly confined to the outer rows. It rarely does any serious general damage to corn, although it is reported to have once destroyed fifteen acres of that crop near Elmira, Illinois, and it has also been occasionally found injuriously abundant in fields of wheat. It is probable that where the injury is not limited to the margins of the field, but is general throughout its area, the eggs were laid in fall in grass or thick-stemmed weeds in corn-fields, where these have sprung up profusely after the corn has been

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laid by. The burrow which the stalk-borer makes within the stem runs upwards from the entrance opening, and of course varies in size with the growth of the larva. Sometimes in leaving a stalk it makes a new hole above that by which it entered, and it may in this way burrow in succession several different stalks and several different kinds of plants. Corn is injured by it while from two to ten inches high.

Besides the corn, wheat, and blue-grass already mentioned, it may infest oats and timothy, various garden crops—including potatoes, tomatoes, rhubarb, and spinach—blackberry and raspberry canes, the thick-stemmed weeds—such as ragweed, burdock, and cocklebur—a considerable variety of garden flowers, and also the new growth of the peach, currant, grape, apple, willow, etc. Indeed, its food plants are so numerous as to indicate a practical indifference to kinds, the only necessary condition being a relatively thick stem, soft enough to allow it to enter and feed freely within. In the small grains and larger grasses, like oats and timothy, it makes its presence manifest by killing or even cutting off the stem within an ensheathing leaf, thus causing the head and the whole plant above the injury to turn white, and presently to dry up. It is only one of several insects which produce this general effect at this time, but its own injury may be at once distinguished by the round hole which it leaves in the stem of the infested plant.

It occurs throughout the United States and Canada east of the Rocky Mountains, but is most destructive in our own latitude, the adult moth having been, in fact, originally described from specimens sent from Illinois to France.

The caterpillar, when full grown, pupates, as a rule, within its last burrow, commonly below the opening at which it entered—seemingly a precaution against its destruction by the withering and breaking away of the upper part of the injured plant. The pupa (Fig. 25, *e*) is light mahogany-brown, about three-fourths of an inch in length, and bears at the tip of the body a pair of spines. From it comes out a fawn-gray or mouse-colored moth (Fig. 25, *a*), with the outer third of the wings paler and bordered within by a whitish cross-line. Other specimens (var. *nebris*) have some white spots on the disks of the wings. The moth is nocturnal, and has been taken by us flying about electric lights, and also at sugar. The eggs have not as yet been found.

There is but one brood in a year, and by the end of June the caterpillars are over half grown, and have mostly left the grasses in which they made their start and entered the thicker-stemmed plants, of course including corn. They live in this stage until late in July, when pupation begins, but larvæ have been found until August 28. The moths begin to appear about the middle of August, and continue throughout September and October. They have never been found in hibernation, and it

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seems likely that they lay their eggs in fall in grass-lands, and that these hatch in fall or the following spring.

The stalk-borer is much infested by parasites, both dipterous and hymenopterous, access being got to the caterpillars, doubtless, during their intervals of wandering while outside the infested plants.

Fortunately, injuries by this insect are not of a kind to require special measures of prevention or remedy. It is, of course, impossible to poison the larva in the corn-field, and the breeding habits of the insect are not such as to enable us to destroy it in the pupa state by any ordinary operation. If headlands and other grassy lots adjoining corn show in early spring an unusual abundance of these insects, it might be worth while to mow the infested turf and carry away and feed the cut grass promptly, before the caterpillars could escape to enter the corn.

A number of other stalk-borers besides the one especially referred to in this discussion, occur in Illinois, all closely related to the preceding, extremely like it in general appearance, and injuring vegetation in an identical manner. Their life histories, so far as we may infer from scattered observations and breeding-cage notes, are practically the same as those of the common species. None of them have been noticed in corn, although some of them may easily have been confused with *nitela* in corn-field collections. These related stalk-borers differ from *nitela* especially in the fact that the longitudinal lines are less developed in some of the species and more so in others.

THE ARMY-WORM.

Leucania unipuncta Haw.

(*Heliophila unipuncta.*)

(Plate II.)

This notorious entomological raider and marauder, although one of the most destructive of the insect pests of American agriculture, is actually noticed and distinguished by individual farmers only when it becomes so numerous as to travel in companies, that is, once in some ten or fifteen years, or so, in any given locality. Indeed, many Illinois farmers of several years' experience have never seen the army-worm at all to know it, and many more would not recognize it with any certainty, if found within their fields and meadows, until it got practically beyond control. It is often very desirable, however, that its presence in grass-lands should be detected before it has begun its career of general destruction, and a good and plain description of it is consequently very much to be desired.

This caterpillar should be looked for especially in the coarser, ranker grass growing in the lower, moister parts of the meadow. In the latitude of central Illinois, it appears in three broods or successive genera-

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tions each year; the first about the middle of May, the second during the latter part of June, and the third in August and September. But one of these generations is seriously injurious during the same year, sometimes the first and sometimes the second, while the third, with rare exceptions, is economically insignificant. The earliest generation (May and early June) is most likely to be the destructive one in southern Illinois, and the second generation (late June and early July) in the central and northern parts of the State. The third generation (August and September) has never been injurious, to my knowledge, in Illinois, but has sometimes been so in New Jersey and New York. The abundant generation moves in hordes or "armies" out of its breeding grounds and into adjoining fields, destroying virtually every green thing as it goes.

Description of the Army-worm (See Pl. II).—This caterpillar has the general appearance of a cutworm, to which, in fact, it is closely related, and whose habits and injuries to vegetation it imitates in ordinary years when it is not unusually abundant. It is readily distinguished, however, from ordinary cutworms by its much more distinctly striped markings, in colors ranging from light greenish yellow to greenish black and black. Looking at the side of the caterpillar, one sees three such stripes very distinctly marked, of which the central one is dark, and the others are lighter. The back of the caterpillar is greenish black, and along the middle of it runs a narrow white stripe, broken and usually indistinct except at each end. Of the three side stripes, the lower one, which is just below the spiracles, is light greenish yellow and is narrowly edged with white. The upper one is a little darker, also edged with white, and with its center greenish black. The middle one of these three stripes, which has the spiracles at its lower edge, is black, sometimes a little lighter along its center. The head is of a greenish brown color, with coarse black mottlings, and with blackish lines where the pieces of the head seem joined together. The belly of the larva is lighter than the back and more or less mottled with blackish. This description applies quite closely to ordinary examples, which the colored plate in this report correctly illustrates. Sometimes, however, paler specimens are found, in which all the colors are less intense, but the pattern is unchanged.

The Army-worm Moth (See Pl. II).—The army-worm hatches from eggs laid by very common night-flying moths. These are yellowish brown, with a white speck near the middle of each fore wing, as shown distinctly in the colored plate. They are fond of sweets, and may be captured in large numbers at night by using sugary substances as a bait.

Habits of the Army-worm.—Army-worms are present every year, and are among the most numerous of our native insects. When present in only ordinary numbers they feed singly in grass-lands like cutworms, remaining hidden during the day, and are then little likely to be seen.

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PLATE II.

The Army-worm, with pupa, moth, and egg.

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Indeed their stripes and colors make them difficult to distinguish among their food plants, and their habit of dropping when disturbed serves still further to conceal them. Their ordinary injuries thus pass unnoticed and their presence undetected unless the grass is so badly damaged as to turn brown in patches, when a close examination may disclose them in their retreats.

Their traveling habit, which has given them their common name, can scarcely be called normal to the species, since they resort to it only under circumstances which are, for them, little less than desperate. When, by extraordinary multiplication, they become so numerous in their breeding ground as to devour their own food supply before they have attained their growth, they must search for more food elsewhere. Unlike many insects under similar circumstances, they exhibit a gregarious habit, and instead of dispersing separately in every direction, as would seem to be the more rational course, they move off together in a definite direction in almost solid phalanx, putting themselves thus to the serious inconvenience of traveling great distances to find their necessary food, and exposing themselves likewise to wholesale destruction by birds and other enemies and to wholesale infestation by insect parasites. Fortunately for agriculture, they likewise expose themselves by this same act to destruction by the farmer, who can annihilate a compact mass of traveling caterpillars although he might be helpless against their attack if they separated and dispersed to all parts of the compass.

Feeding ordinarily upon grasses, they prefer these and grass-like grains, even on their desperate marches. They seem to eat with almost equal relish blue-grass, timothy, wheat, oats, corn, rye, and barley, and will likewise readily take sorghum, Hungarian grass, millet, and flax. In confinement they have grown and completed their transformations when fed exclusively on poppy, beet, lettuce, cabbage, raspberry, onion, parsnip, radish, carrot, or pea, but have declined cotton and grape. Ordinarily clover is not eaten by them, and it is said that the timothy in a mixed field is often eaten to the ground, leaving uninjured the clover scattered through it. A remarkable exception is reported, however, from New Jersey, where in 1880 clover was generally eaten by army-worms in some localities. In the field, besides the plants above mentioned, they have also eaten cranberry, strawberry, bean, sugar-beet, sweet potato, parsley, watermelon, cucumber, apple, pepper, honeysuckle, ragweed, wild *Solanum*, and amaranth.

When they enter a field of young corn they first climb up the plants, eating the blades of the leaves on each side of the midrib, but presently, as they become more abundant, they may virtually devour the whole plant to the surface of the ground. "Fully to realize the destructive capabilities of this insect," says Slingerland, "one must see (no description will suffice) an army of the worms on the march and at work. In

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most cases the caterpillars in each of these armies must have been numbered by the millions; even an approximate estimate of the worms of a single army would have been impracticable. Oftentimes when an army was marching across a lane or roadway, nearly the entire surface of the ground for several rods would be covered by a mass of worms; one could not step without crushing several of them." They feed mostly at night and on cloudy days, although not by any means refraining from travel and feeding in bright weather.

Geographical Distribution.—The army-worm is apparently a North American species, and was well known in New England before the Revolution, where, indeed, measures for the arrest of its movements were adopted which are still the best we can suggest. The species is now distributed throughout nearly the whole world, but it is only in the United States east of the Rocky Mountains and in Canada that it multiplies to a number such as to compel its movements *en masse* in search of food. It is particularly abundant throughout the region from Iowa and Maine to Texas, Alabama, and North Carolina, and in this region there is rarely a year in which it does not somewhere become numerous enough to do serious injury.

Life History of the Army-worm.—The yearly history of the species is not fully known as yet, some diversity of opinion prevailing as to the stage in which it hibernates. Many accurate observations on this subject relate to partly grown caterpillars found late in fall, winter, or early spring, and hibernation in this stage seems to be a somewhat general occurrence. On the other hand, we have taken the moth in March in Illinois, and have once seen it common at lights on April 11. It is also said by Prof. John B. Smith to have been found in New Jersey during the entire winter in sheltered places. We have seen no satisfactory evidence of its hibernation in the pupa stage, although this fact is likewise asserted by some.

When a brood of the caterpillars becomes full grown they rapidly disappear, entering the ground an inch or so, and forming there smooth cavities by twisting about, or making a slight cocoon under clods or other shelter. There they change to smooth brown pupæ (See Pl. II), from which later the moths emerge.

The eggs for the first generation are laid, in our latitude, about the middle of May. These hatch in from eight to ten days. The life of the caterpillar is twenty to thirty days; that of the pupa, twelve to fifteen days; and the moths begin oviposition about a week after they emerge. This gives about seven to eight weeks for the life cycle in midsummer. The eggs (See Pl. II) are placed by the mother moth behind the surrounding sheath of the leaf of grass or grain, from ten to fifty or more together, imbedded in a gummy substance which fastens them also to the leaf surface and closes the sheath around them. It is said that "early

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in the season the moths prefer to oviposit in the cut straw of old stacks, in haystacks, and even in old fodder stacks of corn, or in old bits of corn-stalks scattered about in pastures." Eggs have also been found in the spring in young grain. Slingerland reports that as many as 737 eggs have been found in the body of a single moth—a fact which goes far to account for the tremendous power of reproduction exhibited by this insect.

Until after the second molt the young caterpillars have the looping habit of the measuring-worms, and spin down at the end of a thread when disturbed, as do the canker-worms. They often leave their feeding-grounds when they are scarcely more than half grown. They may travel at the rate of five to ten rods an hour.

Prevention and Remedy.—The fact that two successive generations of the army-worm are never injurious in the same locality is due to the sudden check placed upon their multiplication by a concentration and increase of their enemies of various kinds, the most important of which are insect parasites and parasitic diseases. Birds and ground-squirrels gather for their destruction, but these larger animal enemies are rarely numerous enough to produce any very marked effect upon the traveling horde. Their insect parasites and fungous diseases, on the other hand, presently come to affect them so generally that they perish wholesale either before or after entering the ground for pupation, the soil in such cases stinking with their decayed remains. Parasitic insects have been seen to swarm about them in such numbers that the sound of their flight was like that of a hive of bees.

In case by watchfulness and good luck a farmer detects a colony of army-worms before it has left its native field of grass or grain, he may to advantage surround it by a few deep furrows so plowed that the dirt shall be thrown inward towards the colony, and then either kill the caterpillars as they collect in this furrow in their efforts to escape, or poison them in a body by spraying the vegetation on which they feed with an arsenical poison, like Paris green.

To stop them and destroy them after they have taken up their line of march, deep furrows are plowed in front of them. The straight side of each furrow, which should be the side away from the worms, is trimmed, if necessary, with a spade so that the dirt shall be perpendicular or overhang a little, and post-holes are made in the bottom at intervals of ten or fifteen feet where the caterpillars may collect in quantity as they travel up and down the furrow seeking to escape. Here they may be readily killed by pouring a little kerosene upon the struggling mass in each post-hole, after which they should be shoveled out to make room for another collection.

Prompt and vigorous action is essential to success, since the presence of these insects is often not detected until they are well under way, and their rate of movement is such that acres of corn may be sacrificed by a few hours' delay.

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THE CORN BILL-BUGS.

Sphenophorus parvulus Gyll.
S. venatus Say. (*S. placidus.*)
S. ochreus Lec.
S. pertinax Oliv.
S. cariosus Oliv.
S. scoparius Horn.
S. sculptilis Uhl.
S. robustus Horn.

(Plate III.)

The corn "bill-bugs" are snout-beetles of various size and color (See Pl. III, and Fig. 27 to 34), but averaging rather large, the majority of them dull black, with the surface much marked with small pits and narrow grooves. In form they are somewhat irregularly oval, with thick bodies, rounded above and beneath, and with rather long and thick "snouts" or "beaks" of medium length, curving downward from the front of the head. This so-called snout is really a part of the head itself, and bears always at its tip a pair of minute jaws or mandibles, used in taking in food. The beetles injure and often kill young corn in spring by thrusting the beak into the stem of the plant near its base and eating out the inner tissue beneath the point of puncture. Their presence in the field is very soon made manifest by the appearance of circular or oblong holes running in rows across the blade of the leaf, each row resulting from a single thrust of the beak when the leaves were closely rolled together in the young plant. (See Pl. III.) The injury done varies from insignificance up to complete destruction of practically every plant in several acres of corn and for two or three successive plantings.

The larvæ of these beetles (See Pl. III, and Fig. 26) are rarely found in corn-fields except in some of the Southern States, where one of the species, *robustus*, may live as a larva in the pith of the stalk. The others feed, in the larval stage, so far as known, upon the bulbous roots of grasses, sedges, and the like, or, in the smaller species, upon the fibrous roots of the smaller grasses. These larvæ are thick-bodied, oval, footless grubs, with hard, brown or blackish heads, the first segment behind the head being leathery and smooth and slightly tinged with brown. They are most frequently seen imbedded in the root-bulbs of timothy, or, in swampy situations, in the thick root-bulbs of the common reed, the club-rush, and other very coarse sedges and swamp grasses.

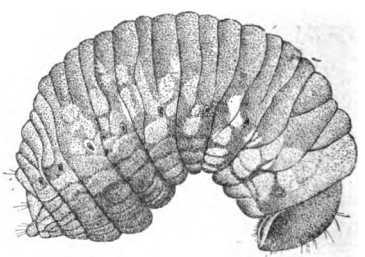

FIG. 26. The Corn Bill-bug (*Sphenophorus ochreus*), larva, side view. Greatly enlarged.

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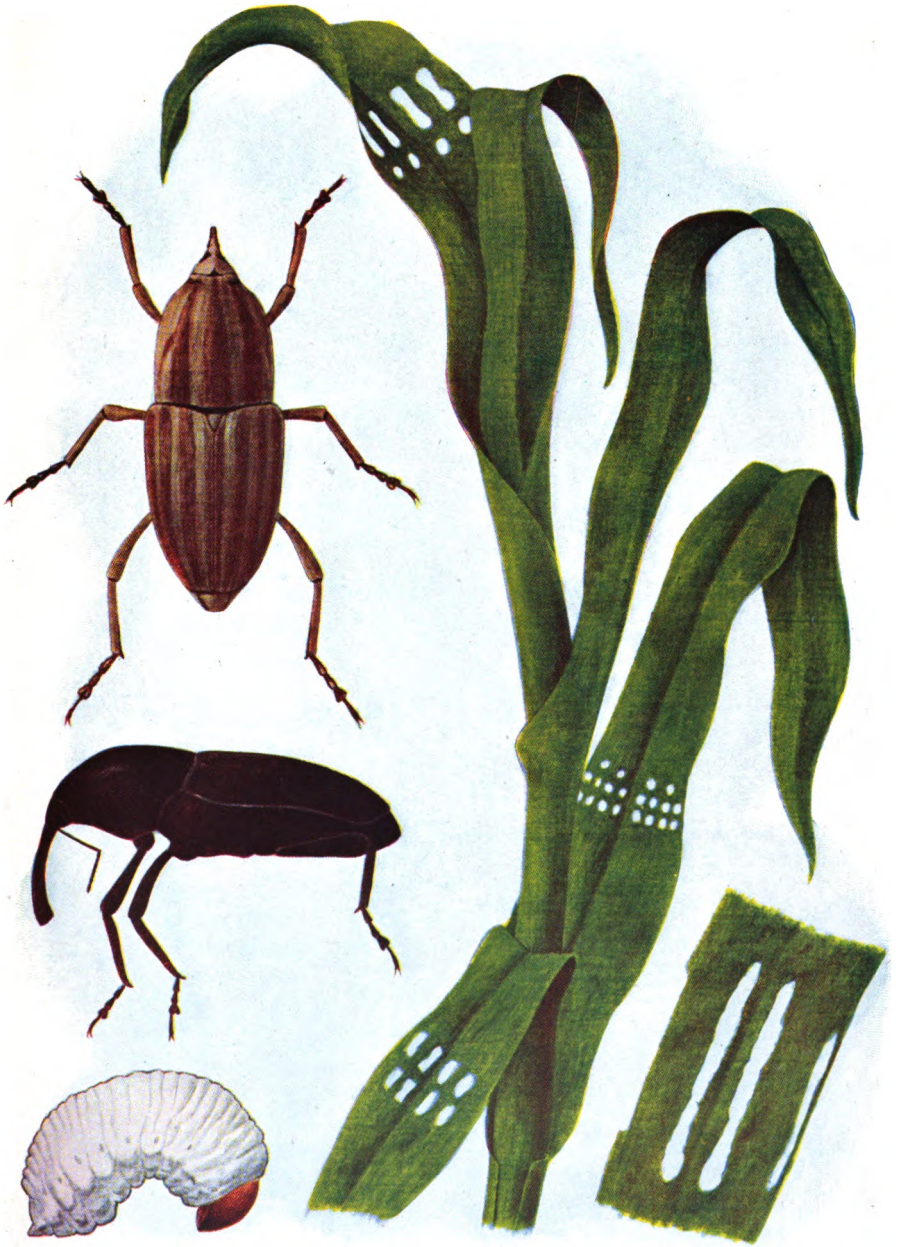

PLATE III.

Corn Bill-bugs and larva, with injured corn plant.

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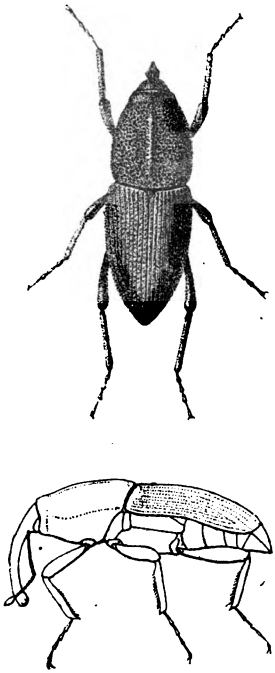

FIG. 27. *Sphenophorus parvulus*, adult, back and side views. Greatly enlarged.

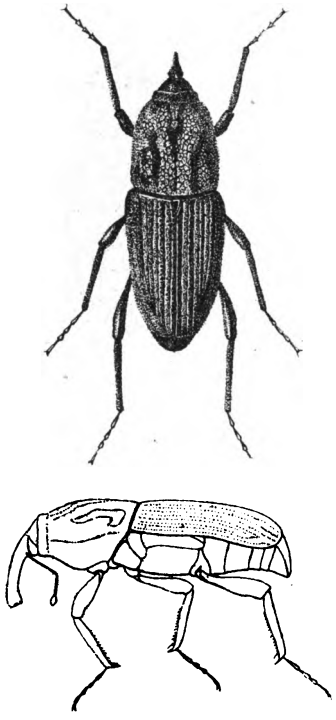

FIG. 28. *Sphenophorus venatus*, adult, back and side views. Greatly enlarged.

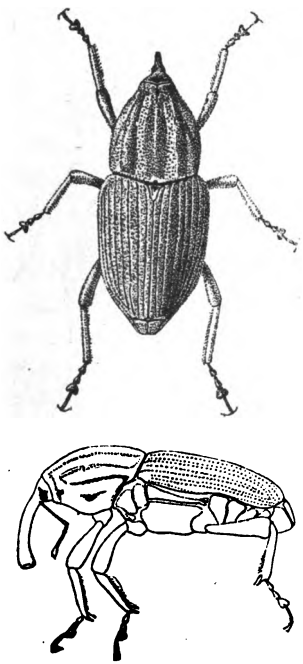

FIG. 29. *Sphenophorus ochreus*, adult, back and side views. Greatly enlarged.

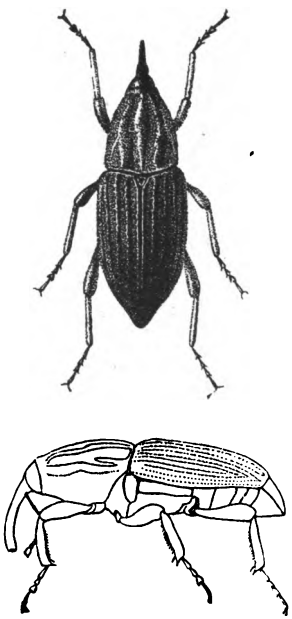

FIG. 30. *Sphenophorus pertinax*, adult, back and side views. Greatly enlarged.

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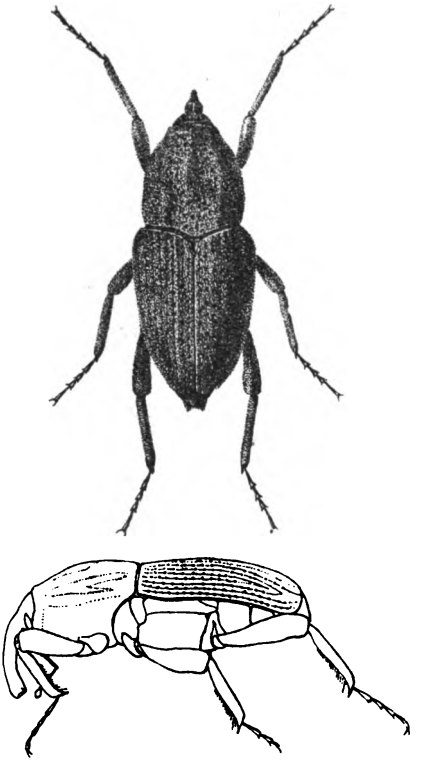

FIG. 31. *Sphenophorus cariosus*, adult, back and side views. Greatly enlarged.

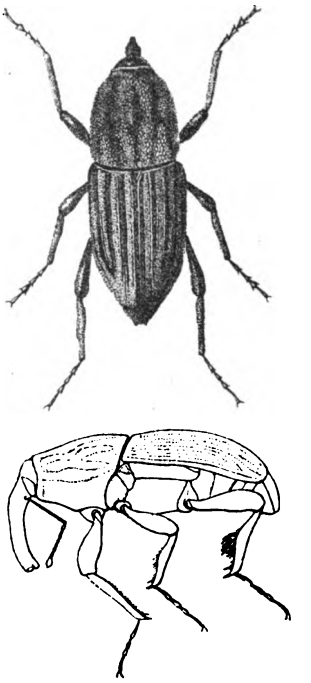

FIG. 32. *Sphenophorus scoparius*, adult, back and side views. Greatly enlarged.

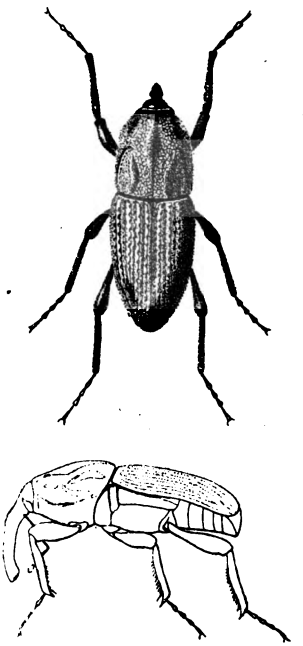

FIG. 33. *Sphenophorus sculptilis*, adult, back and side views. Greatly enlarged.

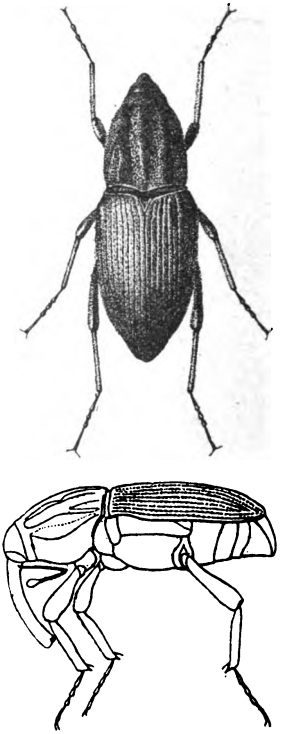

FIG. 34. *Sphenophorus robustus*, adult, back and side views. Greatly enlarged.

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Injuries to Corn.—With the exception of the southern species mentioned above, the injuries to corn are done entirely by the beetles, and are commonly limited to the first year after grass. In some cases where freshly drained swampy tracts have been broken up, the injury may continue in diminished quantity the second year, provided that the crop has not been sufficiently well tilled to kill out thoroughly all the coarse native sedges and grass-like plants. The adults of all the species feed in substantially the same manner, as far as observed, and inflict a similar injury on the plants they infest. Placing itself head downward, with its stout legs embracing and firmly grasping the stalk, the beetle applies the tip of its beak straight against the surface, cutting the outer tissue with the jaws, the action of which is distinctly audible. Gradually, with an occasional twisting motion of the head, it sinks two-thirds or more of its snout into the stalk, and then, slightly rolling its head from side to side with clock-like regularity, it uses its beak as a lever to split the stalk and pry the edges of the slit apart. It pauses from time to time to eat out the soft tissues within, and by moving forward and backward and twisting to the right and left, it hollows out an interior cavity much larger than the surface injury would indicate. Then, pulling the head strongly backward with the compressed beak inserted, the stalk is split upward as a boy would split a stick with a knife. In this way a slit an inch long may be made in the stalk of corn, beneath which all the softer parts have been eaten out.

The injury thus done varies in position from a little below the surface of the ground to the middle or upper two-thirds of the larger leaves. The beetles are often seen at work on young stalks, head downward, with the beak inserted its full length. They are always on the lower part of the plant, from an inch above the ground to a little below it, and two or three of them are sometimes seen on a single stalk. They are not easily alarmed when thus engaged, and a plant may even be cut away, if care is used, without disturbing them. Although they cling closely to it, they can readily be picked off with the fingers, and when thus detached they do not seek to escape, but feign death for a little time.

The effect on the corn plant of such injuries varies according to the size and number of the beetles. A small species like the abundant *parvulus* (Fig. 27) may do little more than to leave a trace of its visit in the form of a series or two of oblong parallel holes across one of the leaves; but the larger species, especially if several beetles attack the same plant, may so rag and deform the young leaves that no ear is matured, or may kill the plant outright.

While there is in Illinois a little general and unclassifiable injury to corn by the bill-bugs, by far the greater part of it occurs under one of three conditions. If swamp lands are broken up from grass in spring and planted to corn the same year, and especially if the common reed

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or the club-rush or other thick-stemmed grasses with bulbous roots are common in the turf, the corn is extremely likely to be badly injured if not wholly destroyed by one of the swamp-loving species of this group. If such land is poorly cultivated, allowing these bulb-root grasses to grow up again, the injury may continue for at least another year. If an old timothy-sod, either pure or mixed with some other grass, is plowed in spring and planted immediately to corn, this crop is likely to be severely injured by other and smaller species than those which attack the crop in swamps. I have known but one case of any considerable injury by these insects to a field of corn in Illinois, except under one of the above conditions.

The damage on swamp sod is frequently so serious and extensive as to require the repeated replanting of large fields of corn. On timothy sod it is not often so complete, a badly infested field rarely having as much as fifty per cent. of the plants injured, and these less seriously because the bill-bugs breeding in timothy average much smaller than those living in swampy situations.

Injuries to Grass and Grain.—The injury to timothy meadows by the work of both beetles and larvæ is sometimes considerable, the former killing the stalk, and the latter destroying an entire stool by hollowing out the bulbous root.

In West Virginia, according to Hopkins, injuries by one of these beetles (*sculptilis*) are among the prime causes of the early decay of timothy meadows. One of the smaller species, *parvulus* (Fig. 27), has also been reported as slightly injurious in the larval state to wheat, oats, and barley. The grub feeds within the straw until it becomes too large for its burrow, and it then passes to the roots, often killing an entire stool of grass in this way.

Distribution.—The known distribution of these beetles is very general throughout the United States and Canada, and in Illinois they may occur anywhere within our boundaries if local conditions permit them to breed.

Life History.—So far as known to me, all our bill-bugs pass the winter in the beetle stage on the ground under rubbish or in other protected situations, and all whose life history has been closely observed, make their appearance in spring usually in fields in which they have lived as larvæ, and where they have fed on the roots of grasses or grass-like plants the preceding year. As the adult beetles feed on the same plants as their larvæ, there is little to tempt them to migrate from one field to another, and the known facts clearly indicate that they pass the winter, as a rule, in the same fields in which they went through their earlier stages, provided that these fields have been undisturbed. All whose life history has been traced with sufficient fulness to warrant an opinion are apparently single-brooded, although the long breeding period and the

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frequency, as a consequence, with which the insects may be found in various stages at the same time have sometimes led to the inference that there were several generations in a year. Injury to corn, however, is in all cases limited to spring and early summer, ceasing altogether by the middle of July even in the most serious cases. Corn not killed or crippled by these insects while it is young soon grows beyond their reach, and they then leave the field in search of more practicable food.

The eggs of the Illinois species studied are laid mainly in May and June in the roots or stems of the plants; larvæ may occur throughout June, July, and August; and the beetles emerge in late summer and in fall.

Measures of Prevention and Remedy.—Probably no steps could be taken to arrest the injury to corn in spring by these beetles, and the only resource at that time must be replanting of the injured hills. To avoid repeated destruction, this should be postponed as late as practicable, but it would be virtually safe after the middle of June. The swamp bill-bugs are likely to continue their destructive work through June and well into July, and with them, consequently, this measure would usually fail, and the only alternative remaining is the planting of the ground to some crop not liable to injury by these beetles. It appears, from observations made in 1902, that injury by the swamp species may be forestalled by breaking up the sod in early fall, and it has also been repeatedly observed that corn growing upon timothy sod of early fall plowing was relatively—usually, indeed, completely—free from bill-bug injury the following spring.

For details concerning the several species the reader is referred to an article on the corn bill-bugs published in my Fifth Report, the sixteenth of this office (1890), and to another on "The Corn Bill-bugs in Illinois," in my Eleventh Report—the twenty-second of the office (1903).

THE CHINCH-BUG.

Blissus leucopterus Say.

(Plate I.)

This notorious insect, one of the very worst enemies of American agriculture, is, on the whole, the most destructive to corn of all the insect species to whose attack that crop is subject. It is true that in some parts of the state it has now been virtually unknown for many years, and that where it is most commonly destructive, periods of several years may succeed each other with no noticeable loss to the corn farmer on its account. There are considerable districts, however, in which it is permanently present in numbers sufficient to do every year more or less injury in corn-fields, varying from what may be described as trifling to the total destruction of the entire crop over many square miles of territory. It is estimated that the total agricultural losses due to the

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ravages of this insect have amounted in single states to from ten to twenty million dollars in a season, and throughout the whole range of the insect to a hundred million dollars or more in a single year.

It must be admitted, however, that the weather conditions under which its injuries become serious are such that the corn would suffer materially from drouth if it were not infested by chinch-bugs at all, and as the effect of the insect attack is virtually indistinguishable from that of excessive dry weather, it is usually quite impossible to separate the effects of these co-operating causes. Estimates of injury by chinch-bugs are therefore exceptionally uncertain.

Description of the Chinch-bug.—Although this insect is so abundant and destructive at certain times and places, its appearances in numbers sufficient to attract attention are often separated by intervals of many years, and multitudes of farmers consequently do not know it at sight.

When full grown (See Pl. I) it is readily distinguished from any other insect of its region by its size and form, and by the peculiar distribution of the white on its back. Looked at from above, the outline of the entire insect is an elongate oval with rather straight sides and broadly rounded ends. Its length is three-twentieths of an inch or a little less, and its breadth about a fourth as much. The head and thorax are black, and all the surface is minutely hairy except that of the wings. The wing-covers, which conceal the abdomen, are milk-white, with a triangular black scutellum between them in front, and a black blotch at about the middle of each side. These invasions of the white area give it roughly the form of the letter X, and this cross mark of white on the back is the characteristic mark of the species. In winged specimens which have recently changed by molting from the preceding stage, the black of the above description is represented by a dull pink, the wing-covers, however, being wholly white, with pinkish veins.

The chinch-bug molts four times after hatching, and changes its appearance materially with each molt. There are thus five distinguishable stages, the first three of which together are often called the red stage of the insect.

In the first of the red stages the young chinch-bug is pale red throughout, with a band of yellowish across the base of the abdomen.

In the second stage the red of the head and the prothorax changes to a dusky tint, and the abdomen becomes a bright vermilion with a pale yellow band across its base, and with faint dusky patches on its posterior segments.

In the third stage, small rounded pads appear on the thorax, projecting backward in the place of the future wings. The head and the thorax are wholly black or dusky, and the abdomen is a dusky red with a patch of darker red near the middle, the light band across its base still remaining, although partly concealed by the wing-pads at its ends.

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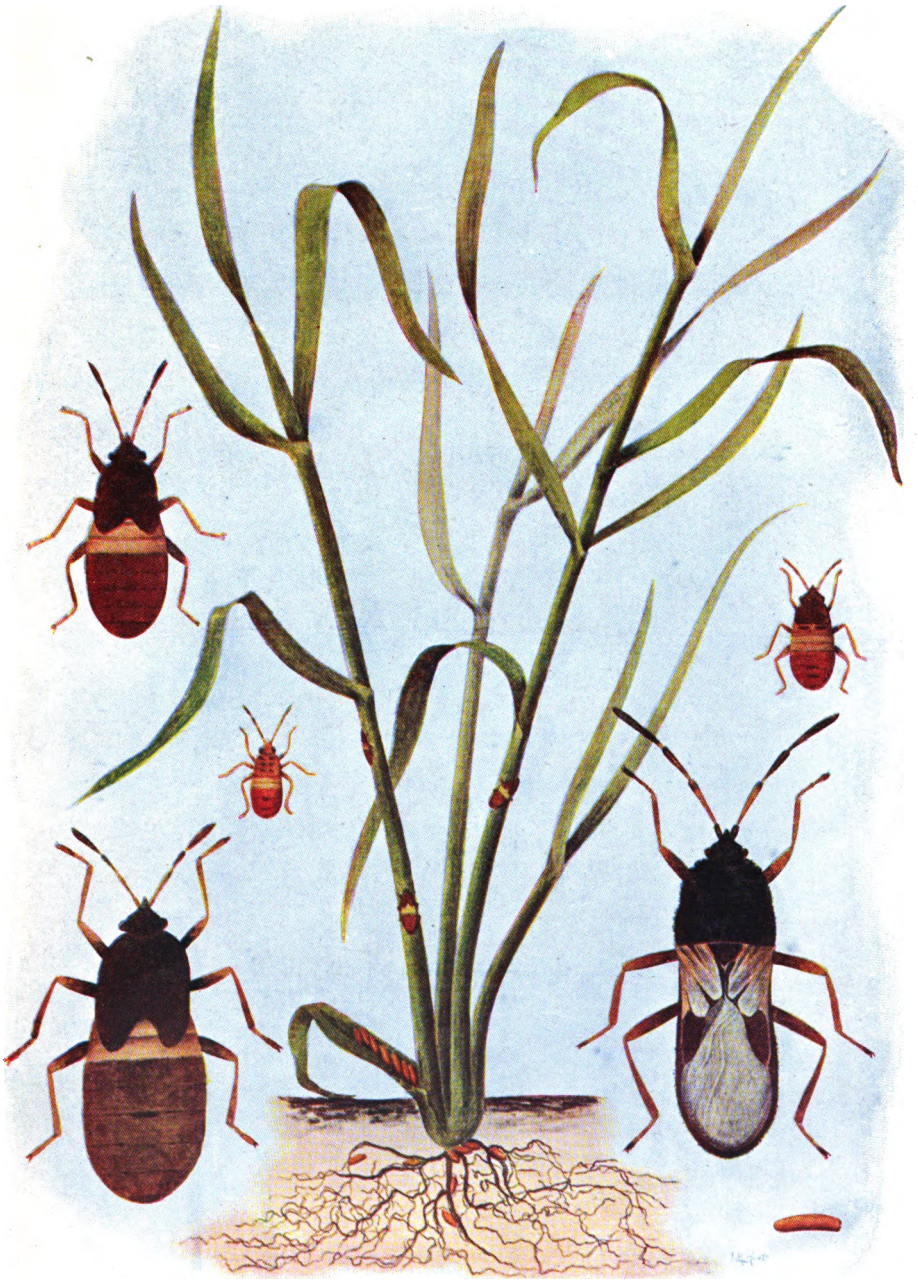

PLATE I.

The Chinch-bug: five stages of development and the egg.

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In the fourth stage the original red color has wholly disappeared, the general tint varying from dusky gray behind to black in front, with a remnant of the pale band across the base of the abdomen showing behind the much enlarged wing-pads. This is sometimes called the pupa stage, and is, of course, the next preceding that of the winged insect.

The egg (See Pl. I) is a very slender oval, about .03 of an inch in length, rather narrowly rounded at one end, and slightly docked or squared at the other, where, under a high magnification, four small rounded tubercles may be seen. Its color is at first whitish and translucent, but later darkens to amber, and finally, as the insect develops within, becomes definitely red.

Food Plants and Injuries to Crops.—The chinch-bug injures all the grasses and cereal crops, but is strictly limited for food to plants belonging to the grass family and to certain wild sedges. It is most destructive to wheat, and next, probably, to corn, although it is likely to damage oats very severely. It infests the meadow and pasture grasses generally, and may destroy them as completely as any other crop; but owing to their perennial growth they afford in spring much less fresh and succulent herbage than the young and delicate plants in fields of corn and wheat. Where spring and winter wheat are grown in the same region, the chinch-bug is more likely to destroy the former, mainly because spring-sown grain is exposed for a longer time to chinch-bug attack before it is harvested. The chinch-bug never injures clover, the cowpea, or any forage crop which would not commonly be recognized as grass; neither does it injure potatoes, beans, or fruiting plants of any description.

There is probably never a year in which the chinch-bug does not injure grass or some cereal in some part of its territory. It is, however, subject to very wide fluctuations in number, becoming at irregular intervals a pest of such frightful character as to appal the agriculturist, and reduce whole districts to temporary poverty. It has, indeed, modified in important ways the agriculture of large sections of our country, leading to the permanent abandonment of wheat culture in many counties of Illinois, and forcing in others the use of leguminous forage plants in place of the grasses and a substitution of orchard culture for the raising of grain and grass.

There is no very definite regularity in the recurrence of its periods of greatest destruction. These are, however, clearly dependent on the periodicity of the weather, injury by the chinch-bug reaching its maximum after several dry years, and being suspended by the occurrence of two or three wet years in succession. The chinch-bug period is, however, less definite and tangible than the weather period, since not every such change in the weather is followed by a notable corresponding change in the chinch-bug situation. The rise and the fall of a wave of chinch-bug

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abundance occupy unequal times, the period of annual increase being longer than the period of decline. Three or four or even five years of notable injury to crops may succeed one another, each worse than the preceding, before the maximum is reached, and then, within a year or two, hordes of these insects which may seem to have taken permanent possession of the fields and meadows over an immense district may disappear so completely that it will be difficult to find a few living specimens.

The injuries by this insect are done by sucking the sap from the plants. Being without jaws for biting, it can only appropriate fluid food by piercing the tissues of its food plant with the hair-like stylets of its beak, and then sucking out the sap from the lacerated cells. Owing to its immense numbers, it may so rapidly drain a strong and thrifty corn plant a foot or two in height that this will wither and fall to the ground as if cut off at the root.

Life History of the Chinch-bug.—The points of special economic interest in the life history of the chinch-bug are the stage and place of its hibernation, and the method of its escape from fields of wheat and other grains at harvest-time. It passes the winter as a full-grown winged insect among the roots of tufted grasses; under stones on grassy knolls; under leaves, sticks, logs, and bark; in thickets and the borders of woods; beneath the rails and boards of fences; and in similar sheltered situations. From these winter quarters it emerges in spring, the exact time varying according to the weather, flies freely about in every direction and to considerable distances, settles most generally in fields of wheat, the young growth of which affords it an abundant and attractive food, deposits its eggs there on the ground about the base of the plant, on the roots a little under the surface, or sometimes on the lower part of the plant above ground (See Pl. I), and presently dies. The eggs are thus laid, in central and southern Illinois, during the last days of April and the whole of May. They begin to hatch about the middle of the latter month, and by the middle of June the old chinch-bugs which had wintered over are virtually all gone.

At harvest-time the young of the new generation are in various stages of development, due to the fact that the eggs are laid at intervals through a period of about a month. There are at wheat-harvest some winged bugs in the field, but the great majority of them are of ages varying from those just hatched up to the stage preceding the last molt. Forced out from these fields of small grain by the ripening of the plants and the consequent pressure of starvation, they enter fields of oats and corn adjoining in a continuous throng, making their migration almost wholly on foot. They thus concentrate in overwhelming numbers on the plants at the borders of the newly entered field, draining and killing everything as they go. It is at this time that the principal injury to

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corn is done, and it is the method of this migratory movement which gives us our special opportunity to protect the corn by destroying the invading army.

When the majority of the brood have acquired wings, flights of the adults occur, resulting in their dispersal through the field. The eggs for a second generation are laid most commonly in corn-fields, particularly on roots of grass-like weeds growing among the corn. This second generation of the year reaches the winged stage late in August and early in September, and leaves the fields in search of winter quarters from the middle of the latter month to about the middle of October.

It should be noted, however, that none of these movements are made simultaneously by all the chinch-bugs of a locality. Even the movement from the winter quarters is a gradual one, and in some cases the chinch-bugs have not all placed themselves for the laying of their eggs before the oats are sown, or even by the time the corn is planted. These crops are consequently likely to become somewhat infested in spring by the first generation of the year, even though there may be an abundance of wheat growing also at the time.

If the weather is very dry at harvest, and especially if drouth and the abundance of the bugs have combined to kill both grain and grass-like weeds by harvest-time, chinch-bugs will desert such fields almost as fast as they can get out of them. If, on the other hand, the grain ripens gradually and normally, and the stubble is left with green weeds interspersed, the bugs are likely to linger for days and even for weeks before the harvested field is completely free of them.

The effect on corn varies with the gravity of the attack. Often in the migration movement every plant of several rows next an infested field of wheat or oats will be blackened by the invading hordes. In such a case the corn is completely killed, and the bugs move forward row by row, carrying the injury, it may be, from one side to another of a field of twenty or thirty acres, and leaving scarcely a living stalk behind. Where they are less abundant, however, they are commonly to be found first and most numerous behind the boots or sheaths of the leaves, where they drain and possibly kill the lower leaves of the plant, checking but not fully arresting its growth.

The second generation, hatching in the corn-field, does much less injury to corn than the migrating one, not because it is less numerous, but because it is more widely dispersed, and also because the corn plant is larger and more thrifty at that season of the year, and can support a loss of sap which would be fatal to younger plants.

A serious minor effect of chinch-bug infestation during the latter part of the season is a consequence of the clustering of the bugs about the base of the stalk of corn where the so-called brace-roots are putting forth. The growing tissues at this point are then so drained of sap that these

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roots do not develop, and the corn, lacking their support, falls to the earth in the first heavy wind, and often fails to form a perfect ear.

Preventives and Remedies.—Without attempting to give in this special article any full program of procedure for the restriction of chinch-bug multiplication or the protection of crops against it, three measures will be discussed as particularly applicable to the corn crop.

A considerable mass of evidence has been accumulated, of both a popular and a scientific character, to the effect that the growing of wheat is favorable to the chinch-bug. This is seemingly due to the fact that the wheat plant offers in April and early May a perfect food to the adult, and likewise to the delicate young as they hatch from the egg, whereas, if this crop is not grown, the bulk of the hibernating bugs must distribute themselves over the meadow grasses, only the later ones establishing themselves in fields of oats and corn. The grasses seem at this season of the year to afford a less abundant and perhaps less nutritious food than does the young wheat plant, and general chinch-bug injury of the first or even of the second grade is rare in districts where no wheat is raised. The abandonment of wheat culture is too drastic a measure, however, for general use, since it would result in the obliteration of that crop over a great part of the so-called wheat belt in the central and north-central states.

The hibernating habit of the insect suggests at once the advantage of what is commonly known as clean farming—the destruction, that is, of all waste and rubbish of every description which may form a winter protection to hibernating insects, and the burning over of all waste places and accumulations of rubbish in early spring before the bugs have scattered abroad. The maintenance of thickets and of woodlands with their coating of leaves and masses of fallen brush is especially favorable to these hibernating insects, and an old rail fence will afford winter harborage to millions of them.

The main dependence of the corn farmer, however, must be the destruction of the bugs as they seek to enter his corn after the ripening of the small grain has forced them to migrate in search of food. As soon as the ripening of badly infested fields of small grain compels the chinch-bug to desert them, if the weather is dry so that the ground may be thoroughly pulverized and kept in a dusty condition, a strip of ground six to ten feet wide should be deeply plowed along the side of the infested field adjoining corn. This strip should then be thoroughly and deeply pulverized, first with a disk harrow and then with a brush, until it is reduced as nearly as possible to the condition of dust. Next a short log eight or ten inches in diameter, or a triangular trough made by nailing two boards together, and afterward loaded with stone, should be dragged endwise back and forth in this strip, the driver riding the log or trough if necessary, until a deep groove or furrow has been made across the line

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of march of the chinch-bug host. The sides of the furrow should be dressed here and there with a hoe, as may be needful to make sure that no passageway out is left for the chinch-bugs which will presently accumulate in the bottom.

If the furrow has been well made, its dusty sides will prove impassable to the bugs which tumble into it, especially as these move at this time almost wholly on foot. If it is so placed that it is directly exposed to the sun, in very warm weather the great majority of the chinch-bugs caught in it will be speedily killed by the heat, the youngest succumbing first, but even adults finally perishing. Nevertheless, to insure their destruction, holes a foot in depth should be made in the furrow with a post-hole digger at intervals of about twenty feet, to serve as traps for the bugs. Here they will accumulate by pints and quarts or even by pecks in a place, according to the number in the traveling horde, and in these holes they may easily be killed by pouring a little kerosene upon them. The post-hole digger may be conveniently used for removing them when dead and for dressing up the holes again.

As the myriads of bugs attempt to escape from the furrow, climbing its dusty wall again and again with desperate persistence, they will gradually lessen the slope by dragging down the dust as they fall back, and some of them may thus make their way out in time. It is consequently necessary that the barrier should be continuously watched and occasionally rectified here and there with a hoe. After a time it will perhaps be most convenient to make another furrow parallel with the first, abandoning the latter or using it for the coal-tar strip presently to be described.

This furrow and post-hole barrier will work to practical perfection so long as the ground can be kept thoroughly pulverized, but even a slight shower of rain is sufficient to destroy it, releasing the imprisoned chinch-bugs and giving free passageway into the threatened field. As a safeguard against this contingency, a barrel of coal-tar should be brought to the field, together with a watering-pot with a tubular spout, and a dipper for dipping out the tar. If a slender line of coal-tar be poured along the bottom of the furrow or on a hardened strip of ground outside, it will serve as a barrier to the progress of the bugs no less complete than that above described. When first applied it will soak speedily into the ground, but a hardened crust will thus presently be formed which will hold the tar until it slowly dries out. It must commonly be renewed about twice a day. Along this strip post-holes may be made as before, in which the chinch-bugs will be caught even though the ground may be thoroughly wet. A single man or boy can guard from eighty to one hundred and fifty rods of the barrier, but he must be in the field early and late.

This method may seem troublesome and costly to the reader of this

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description, but the actual expenditure of labor and money is practically insignificant as compared with the loss of crops which may thus be prevented. Such a coal-tar barrier kept up for a fortnight will commonly protect a field completely, and the average cost for tar at three dollars and a quarter a barrel (the current price in southern Illinois) will be twenty-five cents a day for a line of a hundred rods in length.

If, as a consequence of mismanagement or accident, chinch-bugs succeed in crossing this barrier or enter the corn before it is made, they will accumulate upon the nearest rows, where they may be killed at slight expense by spraying or sprinkling the plants with a mixture of kerosene and soap-suds known as the kerosene emulsion. This is made and applied as follows:

Dissolve a half-pound of soap (hard or soft) in a gallon of water by boiling. Remove from the stove and add two gallons of coal-oil and mix thoroughly by pumping this fluid back into itself by means of an ordinary spray pump. When the emulsion is formed it will look like buttermilk. To each quart of this mixture add fifteen quarts of water and sprinkle or spray upon the corn, preferably before 10 o'clock A. M., or after 3 o'clock P. M. The bugs should be washed off so that they will float in the emulsion at the base of the plant. A teacupful to a hill is generally sufficient, but the quantity must vary with the number of bugs infesting the corn.

The cost of material per acre of corn treated, will be about seventy cents where the plants are practically covered with chinch-bugs, and about thirty cents per acre where it is moderately infested.

By the use of these various measures corn can be effectively protected against chinch-bug injury, and if so handled, will become infested only by flying bugs which, having been allowed to mature, are scattering over the country in search of food and a place of deposit for their eggs. Even this injury, if serious enough to demand treatment, may be arrested by the use of the kerosene mixture just described.

GRASSHOPPERS.

ACRIDIDÆ.

Injuries to corn by grasshoppers are rarely sufficient in Illinois to require special attention. These insects do not breed in corn, but come into it, if at all, from grass-lands near by. They first injure the outer rows by eating away the silks and kernels from the tip of the ears and by eating up the blades of the leaves, sometimes devouring the husks of the young ear. The effect of the first injury is to prevent the fertilization of the

FIG. 35. The Red-legged Grasshopper (*Melanoplus femur-rubrum*). Natural size.

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kernel, thus blasting the ear. At long intervals, when a series of dry years has favored the multiplication of these insects, they become locally destructive in midsummer to grass and small grain, and later to corn. Under these circumstances several of our native species may fly from place to place for short distances in considerable swarms, imitating in a small way the habits of the notoriously destructive Rocky Mountain locust. This latter species does not occur in Illinois, and no grasshopper injury to which we are subject approximates that which sometimes overtakes the agriculturist of the Western States. Our Illinois grasshoppers are subject to destruction by a multitude of enemies, which become, of course, more numerous as the grasshoppers themselves increase in number. As a consequence, two "grasshopper years," so called, rarely succeed each other in the same locality.

FIG. 36. The Olive Grasshopper (*Melanoplus differentialis*). Natural size.

The standard means for destroying grasshoppers has been until quite recently the use of a long, narrow, shallow pan or tray of sheet-iron, commonly called a "hopper-dozer," with a high back of iron or cloth, dragged across the field by hand or by horse-power, after a little kerosene has been placed in the bottom of the pan. Recently, however, a poison mixture particularly attractive to grasshoppers is taking the place of this apparatus, and is doubtless more likely to be used in Illinois wherever active measures against these insects are found necessary.

This mixture, known as the Criddle mixture, is composed of one part, by measurement, of Paris green to 120 parts of horse droppings, preferably fresh; or about a pound of Paris green to half a kerosene barrel of the droppings, with a pound of salt additional if the material is not fresh. Enough water is added to make the mixture soft without being sloppy, and it is then scattered about the field in quantities according to the number of the insects which will be attracted to it for a distance of forty feet. This poison is most effective when fresh, but it will do excellent work when several weeks old.

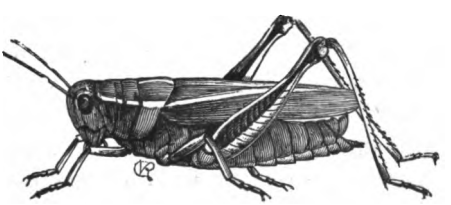

FIG. 37. The Two-striped Grasshopper (*Melanoplus bivittatus*). Natural size. (Riley, U. S. Dept. of Agriculture.)

In speaking of the use of the Criddle mixture, Dr. Fletcher, Dominion Entomologist of Canada, says: "In this section all used the poison and only a few acres of crops were destroyed. I am convinced that had we begun the test earlier, hardly a bushel of grain would have been lost.

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It is not exaggerating to say that dead locusts could be gathered up in wagon-loads, and at times be smelt a half-mile."

The ordinary method of making and using the hopper-dozer is thus given in the Third Report of the State Entomologist of Minnesota, that for 1897:

"A sheet of ordinary sheet-iron, such as is used for making stove-pipes, is turned up one and a half inches around the edges and riveted at the corners. This makes a shallow pan about eight feet long, two feet broad, and one and one-half inches deep. To the bottom of this are riveted six small strips which can be fastened to the three runners on which the pan rests. To the rear side of the pan is screwed a light wooden frame, as long as the pan and one and one-half feet high. Over this frame a piece of canvas is stretched. This frame serves the important office of throwing back all those locusts that otherwise jump clear over the pan, and to throw them into the oil. The runners on which the pan rests are usually made from saplings or small pieces of boards having an upward curve in front to prevent them from catching in the ground. The front ends of the runners are all fastened by screws to a cross-piece, which is, in turn, drawn by two ropes, one at each end. These ropes are joined in front and fastened to a singletree. Sometimes two hopper-dozers are fastened to a long pole by means of short ropes; this is very easily drawn by one horse. Just in front of the pan is fastened a piece of rope which sweeps the ground a few inches in advance and serves to stir up the hoppers and make them jump into the pans. In the pan is laid a piece of cloth, which is first thoroughly saturated with water. About a pint of kerosene oil is then thrown in and the upright sheet or sail of canvas is also moistened with it. The machine is drawn over the fields or wherever the locusts are thickest. In a short time it is usually partially filled with dead or dying insects.

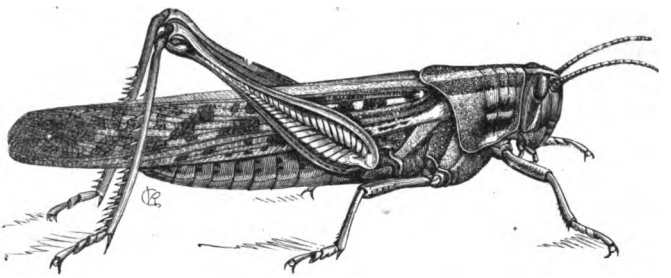

FIG. 38. The Bird Grasshopper (*Schistocerca americana*). Slightly enlarged.

"The slightest touch of kerosene oil, either from the pan or from the canvas sheet behind it, means death to the locust, for the oil spreads over its body in the same way that a single drop of it will spread over a large surface of water. . . . A very large proportion of the locusts that come in contact with the oil in the pan immediately jump out again, but they invariably die in the course of a few seconds or minutes."

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PLATE IV.

The Corn Worm: light and dark individuals, pupa, moth, and egg, with injured ear of corn.

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The various species of grasshoppers injurious to corn in Illinois are so similar in their habits and life history that it is not necessary for any practical purpose to distinguish them, but all may be treated, so far as the corn crop is concerned, as a single economic group. It may be of some interest to know, however, that the most abundant species in corn is the red-legged grasshopper (*Melanoplus femur-rubrum*, Fig. 35), everywhere the commonest of its family in this state. With it is ordinarily associated the heavier and more sluggish olive grasshopper (*M. differentialis*, Fig. 36), with a sprinkling of the two-striped grasshopper (*M. bivittatus*, Fig. 37). In the southern part of the state the lesser migratory locust (*M. atlanis*) and the large conspicuous bird grasshopper (*Schistocerca americana*, Fig. 38) also become abundant, and, like the species *femur-rubrum*, sometimes collect in considerable swarms and make short flights across the country.

THE EAR-WORM OR CORN-WORM.

Heliothis armiger Hübn.

(Plate IV.)

This insect, known also as the cotton boll-worm, the tobacco bud-worm, the tomato-worm, etc., is a slender, nearly hairless caterpillar (See Pl. IV), an inch and a half to two inches long, varying in color from light green to brown, and marked with alternating light and dark stripes and lines running lengthwise of the body. A common type has a dark-brown stripe down the middle of the back, with a fine white line in its center, and bordered on each side by a pale brown stripe, and below the latter a distinct whitish stigmatal stripe. Inconspicuous shining tubercles, each bearing a delicate hair, are arranged in transverse rows on each segment of the body. The head is amber-yellow, and the legs are dark.

As an ear-worm this caterpillar feeds on the corn beneath the husk, from the time the ear is formed until after it is thoroughly ripe, and it also eats the husk, the leaf, the tassel, and the tender stalk. Although it probably prefers corn to any other of its food plants, it is likewise fond of cotton, tobacco, beans, and the fruit of the tomato, and feeds freely upon a great variety of other plants, including pumpkin, squash, peanut, pea, cow-pea, hairy vetch, pepper, okra, jimson-weed (*Datura*), asparagus, ground-cherry, hemp, morning-glory, gladiolus, mallow, mignonette, geranium, sunflower, poppy, and peach. It sometimes devours soft-bodied insects, such as the cabbage-worm and cotton-worm, and has been known to eat the young of its own kind even when vegetable food was plentiful. As a bean insect its injuries in the South are of the most serious character, whole crops being destroyed, and it is also one of the standing and most destructive pests of cotton and tobacco. In the

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truck-garden its injuries to green tomatoes are notorious, although in this work it is aided by a number of other kinds of caterpillars.

It is a cosmopolitan insect, being now found in virtually every part of the world. It is very common in Illinois, where it is most widely known because of its injuries to green corn in the garden and to field corn, particularly in the southern half of the state.

Early in spring it feeds on corn leaves, filling them full of holes the size of small shot, and later in the season it enters the tips of the ears, gnawing away the silk and eating out irregular winding channels among the soft kernels, thus often making its way down below the middle of the ear. A single caterpillar does not confine itself to a single ear, but leaves its work of destruction to be continued by other insects and by fungi, which are likely to follow up its injuries. It bores a round hole through the husk at the side of the ear, and infests others in succession. There are sometimes two or three caterpillars in the same ear, but in that case they are commonly of different ages.

There are three annual generations of these caterpillars in the North, and in the South from four to six, besides a series of broods preceding these, which come from a few individuals that pass the winter as adults. The species hibernates in the pupa stage, and emerges to lay eggs in early April. These range from two hundred to five hundred in number for each female, and are shaped like an inverted teacup (See Pl. IV), with the vertical ribs converging towards the apex and broken up by concentric grooves into little knobs. The caterpillars reach their growth in from two to four weeks, and the moths (See Pl. IV) appear about two or three weeks later. The first brood of caterpillars in Illinois feeds on the leaves and the tender shoots of corn, the second brood devours the tassel, the silk, and the ear, and the third infests the hardened ear. The fourth and fifth broods, where they occur, all attack various plants, particularly the cotton-boll in the South. A sixth generation is reported from Texas. The caterpillar enters the earth for pupation to a depth of from two to five inches, where it forms a slender cocoon by lining the end of the burrow with a few threads of silk (See Pl. IV).

The mastery of this pest in the corn-field is still an unsolved problem. It is believed that late fall plowing of corn-fields which have been infested by this insect will destroy it in the pupa stage by breaking up its underground shelter and exposing it to the vicissitudes of the weather. It is not often practicable, however, to plow corn ground in fall in Illinois, and the effect of such a measure at best can only be to diminish the number of moths in the neighborhood the following year.

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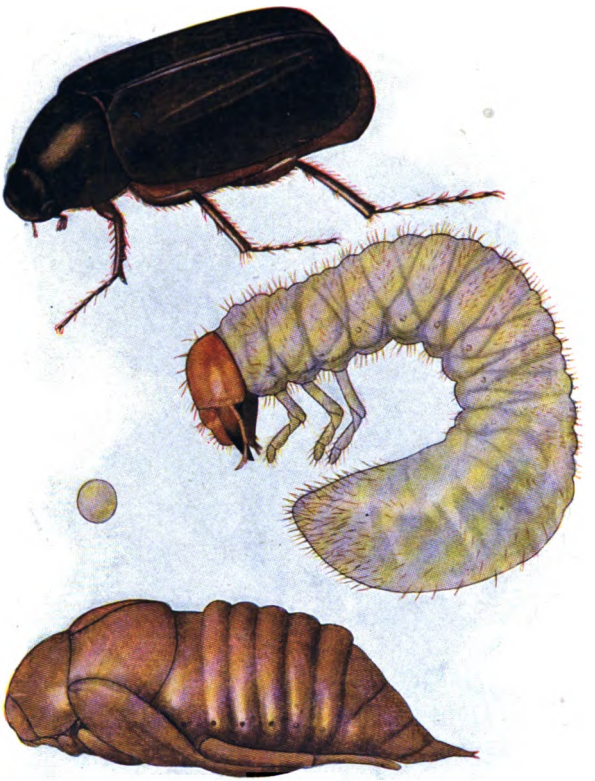

PLATE V.

THE WHITE GRUB. BEETLE, EGG, LARVA AND PUPA.
ENLARGED 2½ DIAMETERS.

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THE MORE IMPORTANT INSECTS INJURIOUS TO THE SEED AND ROOTS.

The following insects injurious to the seed and roots of Indian corn and belonging in this section of "the more important species," have been treated at length in the Eighteenth Report of this office, published in 1894 as an appendix to the Report of the State Department of Agriculture, and also in Bulletin 44 of the Illinois Agricultural Experiment Station, printed in May, 1896:

Wireworms (*Elateridæ*). 18th Rep., pp. 28–51; Bull. 44, pp. 224–233.

The White Grubs (*Lachnosterna* and *Cyclocephala*). 18th Rep., pp. 109–145; Bull. 44, pp. 257–280. (See last plate.)

The Northern Corn Root-worm (*Diabrotica longicornis*). 18th Rep., pp. 154–165; Bull. 44, pp. 287–296.

The Southern Corn Root-worm (*Diabrotica 12-punctata*). 18th Rep., pp. 146–154; Bull. 44, pp. 282–287.

The Corn Root-Aphis (*Aphis maidi-radicis*). 18th Rep., pp. 58–85; Bull. 44, pp. 237–256.

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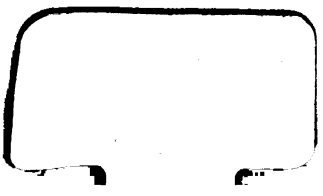

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